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Political Uncertainty Exposure of Individual Companies: The Case of the Brexit Referendum*

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Abstract

This paper studies cross-sectional determinants of the exposure of U.K. firms to Brexit, an event which resulted in an unprecedented rise in political uncertainty. We find that internationalization has a moderating effect on Brexit exposure which goes beyond the pure currency translation effect and is consistent with international activities acting as a diversification mechanism for domestic risks. We also provide some indicative evidence that high-growth firms are more affected by Brexit. At the industry level, we show that Financials and firms in the consumer-facing sectors have the highest exposure to Brexit-related uncertainty. Knowledge of the variation in exposure of individual firms and sectors to political uncertainty associated with major political events can assist managers, investors and policymakers in taking remedial actions to limit its impact.

JEL classification: E65, G14, G18
Keywords: Brexit, Political Uncertainty, U.K.

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"Economics, policy and politics have already taken so many surprising turns in recent years that we believe the only certainty we have is uncertainty."

Valentijn van Nieuwenhuijzen, Head of Strategy at NN Investment Partners,
cited in the *Financial Times* (March 27, 2016)

1. Introduction

On June 23, 2016, the United Kingdom voted for Brexit – withdrawal from the European Union (E.U.) – and this paper analyzes the extent to which individual British companies are exposed to this event. The analysis allows us to get insights into a broader and increasingly important issue: characteristics of individual firms that determine their exposure to uncertainty associated with political events. The Brexit vote, followed shortly by the unexpected election of Donald Trump as the President of the United States, lifted political uncertainty around the world to unprecedented levels (Davis, 2016), yet we know surprisingly little about how this uncertainty affects different firms and industries. Academic literature documents that uncertainty associated with, for example, elections or global summits, affects stock prices at the aggregate level (e.g. Bialkowski *et al.*, 2008; Pastor and Veronesi, 2013; Brogaard and Detzel, 2015; Kelly *et al.*, 2016), however it is reasonable to expect that some firms are more affected than others. Understanding the variation in the exposure of individual firms to Brexit, and to political uncertainty more generally, is important to allow corporate managers to prepare for and mitigate its impact, to allow investors to manage their exposure to individual firms or sectors when political uncertainty is high, and to allow policymakers to understand where the effects of uncertainty are likely to be felt most.

The impact of the Brexit vote on businesses is complex but we posit that, above all, Brexit is an event associated with heightened political uncertainty, as defined in the earlier theoretical finance literature. Pastor and Veronesi (2012) identify political uncertainty as uncertainty about whether the prevailing government policy will change.[1] Similarly, Pastor and Veronesi (2013) broadly interpret political uncertainty as "uncertainty about the government's future actions" (page 521).[2] The context of Brexit fits such a notion very well and therefore the Brexit referendum provides a unique and particularly interesting setup to study political

[1] Pastor and Veronesi (2012) identify so defined political uncertainty as one of the elements of government policy uncertainty. The other element is impact uncertainty which refers to uncertainty about the impact of a new government policy on firms' profitability.

[2] In the model in Pastor and Veronesi (2013), investors react to the flow of political news (political shocks) on the basis of which they update their beliefs about the likelihood of the adoption of various government policies in the future. Political shocks are orthogonal to fundamental economic shocks affecting the supply of aggregate capital and beliefs about the impact of the current government policy.

uncertainty. Unlike parliamentary or presidential elections in which debates focus on selected policies, such as taxation or healthcare, consequences of the Brexit referendum are wide-reaching, affecting many government policies that shape the environment in which British companies operate. For example, the decision to leave the E.U. is associated with uncertainty about the U.K.'s future legal and regulatory framework which is currently driven by E.U. laws and regulations, and it leads to uncertainty about the U.K.'s international trading agreements and immigration policies.[3] Not surprisingly, in the months around the referendum, the news-based U.K. economic policy uncertainty index of Baker *et al.* (2016) sharply increased, far exceeding the levels it reached during the financial crisis of 2007-2008 and the Eurozone crisis of 2011-2012.[4]

To measure a firm's exposure to Brexit uncertainty we use stock market data from the pre-referendum period and from around the referendum result day.[5] We estimate two alternative measures of Brexit exposure. First, we estimate it as the link between the firm's daily stock returns and changes in the probability of a leave (Brexit) vote calculated from bookmakers' odds over four months of the referendum campaign. Second, we apply a standard event study approach and measure the firm's stock price reaction to the referendum result. We find a high degree of correspondence between the two measures of Brexit exposure. For both measures we find a large cross-firm variation which indicates that individual companies are differently exposed to the uncertainty associated with Brexit. We then explore this variation in a set of cross-sectional tests.

We are particularly interested in the effect of the firm's internationalization on its Brexit exposure. Our primary measure of a firm's internationalization is the number of foreign countries mentioned in its annual report but our results hold when we measure it via foreign sales or foreign assets. We find that more internationally-oriented firms are less affected by the

[3] The complexity of Brexit-related political uncertainties that U.K. companies face can be illustrated by the following statement in the Principal Risks section of the 2017 Annual Report of Rolls-Royce Plc (page 59): "While we wait for political certainty from the Brexit negotiations and details of the final Brexit deal, we have assessed potential additional operational impacts to understand what action Rolls-Royce might need to take before Brexit occurs in 2019. We could be impacted through a number of routes. For example: our regulatory relationship with the EU (European Aviation Safety Agency; REACH chemical certification programme); our operational relationship (customs union and movement of people); our tax and treasury strategy; our EU R&T funding relationship and other interfaces."

[4] The index reached between 429 and 479 points during the referendum campaign in March-May, 800 points in June and an all-time-high of 1,142 points in July 2016. During the financial crisis of 2007-2008 it reached a maximum of 251 points in October 2008, and during the Eurozone crisis of 2011-2012 the maximum was 408 points in November 2012. The long-term average monthly value of the index between January 1997 and June 2017 is 161 points. The index is available at www.policyuncertainty.com.

[5] As Estrella and Mishkin (1998) argue, beyond forecasting accuracy, employment of leading financial indicators, such as the stock market, "allows the economic analyst to think about the causal relationships that may lead to a specific result" (page 45).

uncertainties of Brexit. Our finding is consistent with diversification benefits of international activities; companies can diversify domestic risks and hence reduce their negative impact by operating internationally, assuming that risks are not perfectly correlated across countries (e.g. Shapiro, 1978; Fatemi, 1984; Kwok and Reeb, 2000; Beaulieu *et al.*, 2005). We rule out the possibility that our result is solely driven by the effect of the weaker pound (GBP) in response to Brexit, which increased the pound-denominated value of foreign sales or assets. The diversification benefits of internationalization appear to dominate the impact of uncertainty regarding foreign trade agreements or regulations, important issues related to Brexit, which would be expected to adversely affect firms with international operations (e.g., Boutchkova *et al.*, 2012; Handley and Limao, 2015).

To further test the diversification effect, we divide international exposure into European and non-European. In line with the expectation that Brexit effects are likely to ripple through the rest of Europe, we find that European exposure provides a weaker diversification mechanism, and the beneficial effect of internationalization is driven by non-European exposure. We confirm that the statistically significant effect of internationalization on how companies are affected by Brexit-related uncertainties does not capture the effect of firm size or industry-specific effects since the results hold after controlling for them.

In the cross-sectional analysis we also explore the impact of the firm's growth and investment opportunities on its Brexit exposure. We find some evidence that growth firms are more exposed to Brexit uncertainties, in line with our expectation, however our results allow us to draw indicative rather than definitive conclusions.[6] We base our expectation that growth firms are more exposed to Brexit uncertainties on theoretical arguments (e.g., Bernanke, 1983; Aizenman and Marion, 1993; Bloom, 2009; Pastor and Veronesi, 2012) and empirical evidence (e.g. Julio and Yook, 2012; Baker *et al*, 2016; Hassan *et al.*, 2016) that firms cut investment and reduce employment when political uncertainty increases. Growing firms and firms with greater investment opportunities are likely to require uninterrupted investment in physical and human capital to exploit those opportunities, and therefore these firms would have a larger exposure to political uncertainty.

Among the control variables we find that larger firms are more affected by Brexit and we also provide some evidence that more profitable firms have lower exposure. Other fundamental firm characteristics, such as leverage and liquidity, are insignificant. Furthermore,

[6] The significance of individual empirical proxies depends on the measure of Brexit exposure and regression specification.

we find no significant link between Brexit exposure and foreign ownership, reliance on the European Single Market[7] workforce, labor intensity or the extent of E.U. lobbying.

The industry-level analysis reveals that Financials and firms in the Consumer Goods and Consumer Services sectors have the highest Brexit exposure. There are alternative channels through which Brexit uncertainties could translate to higher Brexit exposure for financial firms. First, politically-induced uncertainty leads to weaker future overall economic conditions (e.g. Fernandez-Villaverde *et al.*, 2015; Baker *et al.*, 2016) which negatively affects profitability of banks and other financial institutions. Second, U.K. financial firms are affected by the uncertainty regarding international agreements on access to foreign markets, including passporting rights which allow financial firms based and regulated in one European Economic Area (E.E.A.) country to operate freely in any other E.E.A. country. The high Brexit exposure of consumer-facing companies is in line with evidence that households reduce consumption and increase savings in periods of higher policy uncertainty (Giavazzi and McMahon, 2012).

Firms in the Basic Materials and Healthcare sectors have the lowest exposure to Brexit uncertainties. Companies in those sectors are mainly multinational firms with operations diversified across countries and are less dependent on domestic market conditions. Our empirical analysis suggests that the sector-wide effect reflects the aggregation of the benefits of international diversification at the level of individual firms.

This paper complements existing studies which examine the impact of similar single political events on stocks: Beaulieu *et al.* (2005) analyze the 1995 Quebec independence referendum and Acker and Duck (2015) the 2014 Scottish independence referendum.[8] Our setting and sample allow a more comprehensive analysis of political uncertainty exposure at the level of the individual firm than these existing studies. The limited exposure of U.K. firms to the Scottish independence referendum restricts the ability of Acker and Duck (2015) to explore cross-sectional variation in exposure, and Beaulieu *et al.* (2005) analyze portfolios of stocks across a relatively limited sample of 71 firms. Our regressions are run at the firm level on a much larger sample of almost 300 companies, which also improves the power of our test statistics. The firm-level analysis in this paper also complements a study by Boutchkova *et al.* (2012) who provide a cross-country, industry-level analysis of political risk exposure. They find that higher political risk leads to greater return volatility for industries more dependent on

[7] See Appendix A for definitions.

[8] The link between the behavior of financial markets and changing probabilities of a single election outcome is also analyzed by Gemmill (1992) for the U.K. 1987 parliamentary elections, and Knight (2006), Snowberg *et al.* (2007) and Wolfers and Zitzewitz (2016) for the U.S. presidential elections in 2000, 2004 and 2016, respectively.

foreign trade, contract enforcement and labor. The findings of Boutchkova *et al.* (2012) in respect of foreign trade contrast with those of Beaulieu *et al.* (2005), who find that firms with international exposure are less affected by political risk than firms without international exposure. We offer new evidence on these contradictory findings; we find that companies with more foreign activities are less affected by political uncertainty in relation to the Brexit vote, in line with Beaulieu *et al.* (2005). Furthermore, our cross-sectional evidence extends findings of a recent study by Liu *et al.* (2017) who analyze the impact of the Bo Xilai political scandal on stock prices of Chinese firms. They show that firms which are more sensitive to monetary and fiscal policy and firms with political connections are more affected when political uncertainty increases.

The remainder of the paper is structured as follows. Section 2 provides a theoretical basis for the firm-level determinants of political uncertainty exposure related to Brexit. Section 3 presents the Brexit exposure measures and Section 4 provides empirical evidence on cross-sectional determinants of the exposure. Additional tests and robustness checks are presented in Section 5, and Section 6 concludes the paper.

2. Determinants of Brexit Exposure – Theoretical Background and Motivation

To develop predictions regarding the determinants of Brexit exposure we refer to the theoretical and empirical literature on political uncertainty. We also look at factors specific to the U.K.'s links with the E.U. and the European Single Market to highlight uncertainty regarding policies which may change after Brexit.

2.1. Internationalization

The literature provides different perspectives on the link between exposure to political uncertainty and internationalization. On the one hand, a firm can be viewed as a portfolio of projects or activities and if they are spread internationally, the firm can potentially benefit from diversification (e.g. Shapiro, 1978; Fatemi, 1984; Kwok and Reeb, 2000). According to that view, companies can diversify domestic risks by operating internationally, assuming that risks are not perfectly correlated across countries. In the context of our study, even though the consequences of Brexit are expected to spill-over to other countries, they are most severe locally, in the U.K., with the effect being more muted elsewhere, particularly beyond Europe. Therefore, we expect firms with larger foreign activities to be less exposed to Brexit-related uncertainty. This is supported by Beaulieu *et al.* (2005), who argue that a company with operations diversified geographically across different domestic markets can more easily shift

operations from one market to another and hence minimize the adverse impact of political uncertainty on costs of inputs, output prices or interest rates. They find that a portfolio of Quebec firms with foreign subsidiaries was less affected by increased political uncertainty associated with the Quebec independence referendum. Cao *et al.* (2017) show that firms increase cross-border acquisitions before elections which raise political uncertainty in the home market, demonstrating that internationalization can be a hedging mechanism against domestic political uncertainty. In the extreme, firms with established international operations, for example foreign subsidiaries, can escape political uncertainties in the home market by relocating or re-registering abroad.[9]

The benefit of hedging local political uncertainties by international diversification is not the only reason why internationalized firms can do relatively better when political risk increases. An additional financial benefit can come from currency translation effects. When the local currency depreciates in the period of higher political uncertainty, as was the case for the pound around the Brexit referendum, the value of local-currency denominated foreign sales or assets increases, increasing the value of the firm.

The above outlined benefits notwithstanding, some authors argue that firms with a higher degree of internationalization can potentially be *more* affected by political uncertainty. Boutchkova *et al.* (2012) argue that firms that rely on foreign trade are more affected when political uncertainty increases because the possible changes to trade agreements or regulations increase risks of their operations. As a consequence, future cash flows are much less certain for firms operating internationally than for firms with a domestic focus. The empirical evidence in Boutchkova *et al.* (2012) confirms that returns of firms more dependent on foreign trade are more volatile when political uncertainty increases.

The arguments are formalized in a model by Handley and Limao (2015). They show that trade policy uncertainty reduces the present value of profits from foreign operations, and therefore a firm's export investment and foreign sales. A similar argument applies to Brexit. Leaving the E.U. increases uncertainty about future tariffs between the U.K. and the E.U., and also between the U.K. and non-E.U. countries with which the E.U. has trade agreements, which can be expected to have a negative impact on British firms with international sales.

[9] In the context of Brexit, a possible relocation was mentioned by several British companies with an international footing; see e.g. 'HSBC warns of economic risks of UK pulling out of Europe', *Guardian*, April 24, 2015; 'EasyJet Opens Talks Over Post-Brexit HQ Move', *Sky News*, July 1, 2016; 'Javid: Single Market Access 'Number One Priority'', *Sky News*, June 27, 2016.

Boutchkova *et al.* (2012) and Handley and Limao (2015) develop their arguments focusing on the impact of political uncertainty on exporters, however, the arguments can be extended to firms operating in complex international supply-chains or relying on international collaboration. Firms may lose suppliers, or the cost of supplies may go up, if the terms of trade become uncertain, implying that altogether firms with a higher level of internationalization are more affected by political uncertainty compared to domestic firms.

Brexit-related uncertainties are also expected to negatively affect British firms with international operations which are subject to specific regulations, such as licensing or standardization. For example, financial firms located in London, one of the world's leading financial centers, can currently freely operate in any European Economic Area country based on passporting rights. The Brexit vote brings considerable uncertainty regarding their future status and ability to operate internationally. Similar concerns about the negative effects of Brexit uncertainty were raised, for example, by chemical companies currently subject to European REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) regulations.[10]

Taken together, given the different arguments presented above, the link between a firm's internationalization and its exposure to Brexit-related political uncertainty remains an open empirical question.

2.2. Growth and Investment Opportunities

The value of the firm can be seen as the sum of the value of assets in place and future growth opportunities, where the value of those opportunities depends on the firm's discretionary future investment (e.g. Myers, 1977). Myers (1977) notes that firms are valued on a going-concern basis and the value of the firm incorporates an expectation of the firm's continued investment. However, political uncertainty affects discretionary investment decisions and hence has an impact on firms' ability to exploit their growth and investment opportunities.

The link between political uncertainty and investment has been studied in both theoretical (e.g., Bernanke, 1983; Aizenman and Marion, 1993; Bloom, 2009; Pastor and Veronesi, 2012) and empirical literature (e.g. Julio and Yook, 2012; Baker *et al.*, 2016; Hassan *et al.*, 2016). From a theoretical perspective, uncertainty increases the value of an option to delay an irreversible investment project. In periods of higher uncertainty, firms decide to

[10] 'Brexit Uncertainty Threatens Chemical Exports, Key Lawmaker Says', *Bloomberg*, October 25, 2017.

postpone investment projects and take a 'wait and see' approach, waiting for new information to arrive and uncertainty to reduce. In support of this theoretical view, *inter alia*, Julio and Yook (2012) find that firms significantly reduce investment in election years, when political uncertainty is high. Furthermore, Baker *et al.* (2016) and Hassan *et al.* (2016) document that political uncertainty leads firms to reduce employment.

In the cross-section of firms, the larger the proportion of the value of the firm in growth options, the more sensitive is the firm to future investment decisions. Since political uncertainty affects discretionary investment decisions, firms with higher growth opportunities are expected to be more sensitive to the changes in political uncertainty. Consequently, we expect that growing firms and firms with greater investment opportunities have a larger exposure to the uncertainty associated with Brexit.[11]

2.3. Other Factors

In this section we present other factors we consider to be potential determinants of the exposure to uncertainties associated with Brexit, which we control for in our analysis.

We consider firm size for two reasons. First, we would like to appropriately identify and isolate the effect of internationalization, discussed above, which is potentially correlated with firm size (for example, foreign activities require a certain level of initial investment and hence only larger companies are able to afford it). Second, various theoretical arguments suggest that firm size can be a determinant of the exposure to political uncertainty but the sign of the expected effect is ambiguous. On the one hand, the literature on political uncertainty and political connections suggests greater exposure for large firms. Pastor and Veronesi (2012) show that larger firms command a higher government policy uncertainty risk premium because their capital covaries more closely with aggregate capital. According to the political cost hypothesis (Zimmerman, 1983), larger firms are subject to greater government scrutiny and hence we expect that they are more likely to be exposed to uncertainty about future government actions. These arguments are illustrated by evidence that larger firms, more often than small firms, have a politically connected board (Goldman *et al.*, 2009), and lobby more (Borisov *et al.*, 2016). On the other hand, large firms are more stable and less likely to get into financial

[11] Early anecdotal evidence suggests that some U.K. companies deferred investment in response to the Brexit vote; see e.g. 'AstraZeneca chief demands clarity on post-Brexit landscape', *Financial Times*, July 29, 2017 and 'Burberry puts UK trenchcoat factory on hold', *Financial Times*, July 14, 2016.

distress in the period of increased uncertainty associated with Brexit. This last argument predicts a negative link between firm size and Brexit exposure.

Other factors we look at are the firm's financial strength and financial constraints. We argue that uncertainty about economic policies leads to weaker future overall economic conditions (e.g. Fernandez-Villaverde et al., 2015; Baker et al., 2016) and since flight to quality (see, e.g. Bernanke *et al*., 1996) suggests that the costs of economic turmoil rise disproportionately more for firms in a weaker financial position, we suggest that firms in a weaker financial position, *ceteris paribus*, have greater Brexit exposure.

We also consider the effect of foreign ownership. International investors are less exposed to risks in a specific country as they diversify across countries and hence we expect U.K. firms with a larger fraction of outstanding shares held by foreign investors to be less exposed to Brexit. However, less-than-perfect market integration is required to achieve benefits of international portfolio diversification and Bekaert *et al.* (2011) show that developed equity markets have been effectively integrated over the last two decades. Nonetheless, they document that market integration is time-varying and it decreases in periods of market uncertainty, offering scope for potential benefits given that Brexit raises market uncertainty.

We also look at firm level political activity. In the context of Brexit we examine the firm's lobbying activities in E.U. institutions (European Parliament and European Commission) to determine the extent to which a firm is connected to the existing E.U. political setup. E.U. lobbying indicates the firm's reliance on the E.U., for example its legislation or funding and thus firms which lobby would be expected to be more affected by Brexit uncertainty. Liu *et al.* (2017) show that Chinese firms with greater connections to the current political setup are more affected by a disturbance to the Chinese political system. On the other hand, since lobbying can also be used to actively manage political uncertainty exposure (Akey, 2015; Hassan *et al.*, 2016), firms which lobby more can be less exposed to political uncertainty.

The political discussion in the run-up to the Brexit referendum revolved around immigration; the European Single Market is associated with the freedom of movement of people. The Brexit vote is therefore linked with uncertainty about future government immigration policies and, in particular, the access of E.E.A. and Swiss citizens to the U.K. labor market. Therefore, we expect that firms reliant on the single market workforce, and, more generally, labor intensive firms, have higher political uncertainty exposure in the context of Brexit.

3. Measuring Political Uncertainty Exposure Associated with Brexit

3.1 The Link between Stock Prices and Brexit Probability – Brexit Beta

We start by estimating the Brexit exposure for each firm as the link between its stock returns and changes in the probability of a Brexit vote using the following time-series regression:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}, \quad (1)$$

where r_{it} is the return on stock i on day t and x_t is the change in the probability of a leave (Brexit) vote on day t calculated from bookmakers' odds, as defined and discussed in detail below. The estimation is similar to the approach in Snowberg *et al.* (2007) who measure the link between financial market movements and changes in George W. Bush's chances for re-election in 2004 and in Wolfers and Zitzewitz (2009) who estimate the market impact of changes in the probability of the 2003 Iraq war.[12] The model is estimated separately for each firm using daily data over the period between February 20, 2016 (the day the referendum was announced), and June 22, 2016 (the day before the referendum). The sample period includes 84 trading days. In Section 5 we show robustness of key findings of the paper and provide a series of additional tests in which we extend Model (1) to include additional control variables, such as the market (FTSE All Share index) return or global macro factors and general market uncertainty captured by changes in the S&P500 and VIX indices.

β_{Bi} estimated in Model (1) is our coefficient of interest and we interpret it as firm i's Brexit exposure – 'Brexit beta'. We posit that an increasing (decreasing) probability of a Brexit vote is associated with increasing (decreasing) political uncertainty. If political uncertainty commands a risk premium (Pastor and Veronesi, 2013) and if it negatively affects economic growth and hence future cash flows (e.g. Bernanke, 1983; Aizenman and Marion, 1993; Bloom, 2009; Fernandez-Villaverde *et al.*, 2015), an increase (decrease) in the probability of a Brexit vote is expected to lead to a decrease (increase) in stock prices. Therefore, we expect, on average, that Brexit betas will be negative across our sample firms. For each individual firm, where the Brexit beta is more negative, the Brexit exposure is greater.[13]

[12] Our overall empirical approach is also similar to the methods used in the earlier literature to estimate the foreign exchange exposure of individual companies (e.g. Jorion, 1990; He and Ng, 1998).

[13] When talking about Brexit uncertainty we refer to the policy uncertainty associated with an eventual leave vote. Goodell and Vähämaa (2013) highlight the difference between election outcome uncertainty and political uncertainty. Election outcome uncertainty increases where the probabilities of the opposing options move towards 50/50. Political uncertainty reflects the uncertainty in policy related to a particular outcome. Throughout the referendum period the leave vote probability that we employ remained below 50%, and thus an increase in the leave vote probability reflected both increased election outcome uncertainty and increased policy uncertainty.

The change in the probability of a leave (Brexit) vote, x_t, the explanatory variable in Model (1) is calculated as:

$$x_t = \frac{prob_t^{Leave} - prob_{t-1}^{Leave}}{0.5 - prob_{t-1}^{Leave}}, \quad (2)$$

where $prob_t^{Leave}$ is the average implied probability of a leave vote on day *t*, calculated across the four largest fixed-odds bookmakers in the U.K.: Coral, Ladbrokes, Paddy Power and William Hill. Scaling the daily change in the probability by the distance from the 50/50 probability of the dichotomous leave/remain outcomes captures the relative significance of the change in the probability;[14] for example, a two-percentage point change (equivalent to, roughly, one standard deviation of daily changes in our sample, as reported below) is more meaningful when the gap is 10 percentage points than when it is 30 percentage points (approximately the minimum and maximum gap in our sample). However, in Section 5 below we show that our results are robust to alternative approaches to calculating x_t, including scaling the change in the probability by the previous day's probability or not scaling the daily change in Brexit probability.

For each bookmaker *j*, the probability of a leave vote is calculated as:

$$prob_{jt}^{Leave} = \frac{1/odds_{jt}^{Leave}}{1/odds_{jt}^{Leave} + 1/odds_{jt}^{Remain}}, \quad (3)$$

where $odds_{jt}^{Leave}$ ($odds_{jt}^{Remain}$) is the end of day *t* decimal odds offered by bookmaker *j* on the leave (remain) outcome of the referendum. The data on odds are sourced from Oddschecker. Odds can be updated 7 days a week but for consistency with the stock return measures, x_t, used in Model (1) is calculated on the basis of probabilities measured on stock exchange trading days only.

[Figure 1 and Table 1 about here]

The probability of a Brexit vote over the sample period is presented in Figure 1, and Table 1 presents relevant descriptive statistics of the measure and scaled changes in the probability of Brexit, as defined in Model (2). Throughout the sample period the probability of a Brexit vote remained below 0.5, with a minimum of 0.179 on May 26 and a maximum of 0.392 on June 15. The descriptive statistics of x_t are presented in the fourth row of Table 1 ('Change in Probability Scaled by Lagged Gap'). The minimum of -1.009 indicates that the largest drop in the scaled probability of Brexit was observed when the previous day's gap

[14] As shown below, the gap was positive throughout the sample period which makes the interpretation easier, and it was never close to 0.50 which would have driven the denominator of x_t to zero and hence x_t to infinity, distorting its statistical properties.

between the leave probability and 0.5 approximately doubled, while the largest change in the opposite direction was observed when the gap narrowed by roughly a third (0.323). The median daily change is zero, and the mean daily change of -0.012 reflects the overall slight decrease in the probability of a Brexit vote from 0.314 at the beginning of the sample period to 0.245 on the day before the referendum.

It is possible that the link between stock returns and changes in the probability of a Brexit vote reflects reverse causality: i.e. movements in financial markets affect revisions of bookmakers' odds. We argue that such a possibility is not very likely in our setup. First, it is difficult to claim that stock prices of any individual company would influence bookmakers, and our estimation is at the level of the individual firm. Second, we estimate the model at the relatively high frequency of daily observations, whereas any potential reverse causality is only likely to lead to biases in estimated coefficients at lower frequencies (Snowberg *et al.*, 2007).

3.2 Probability of Brexit – Validation of the Measure

Ex post it is clear that the prediction based on bookmakers' odds was wrong, as on June 23 51.9% of the voters voted in favor of an exit from the European Union. The outcome brought bookmakers into the spotlight with commentators casting doubt on the usefulness of their odds as a basis for predictions.[15] Below we offer several arguments to validate the use of the measure based on bookmakers' odds in our empirical tests.

Even though the prediction based on the odds proved incorrect *ex post*, there is no clear reason to argue that the odds were uninformative *ex ante*. First, given the specific nature of referendums, a parallel could be drawn between the Brexit referendum and the 2014 Scottish independence referendum when bookmakers' odds proved to be a good predictor of the result (Acker and Duck, 2015). Second, possibly linked to the success in predicting the Scottish referendum result, bookmakers' odds received substantial media attention in the run-up to the Brexit referendum with revisions in odds reaching news headlines.[16] An online search of the Financial Times archives for articles containing the words 'Brexit' and 'bookmakers' in the body of the text returns 42 items during our sample period of 84 trading days. Third, it is reported that the odds were tilted by larger bets placed on remain compared to leave[17] but if the larger flow of money put on remain was fairly constant throughout the sample period, it

[15] See, e.g., 'EU Referendum: How the bookies got it so wrong over Brexit', *independent.co.uk*, June 24, 2016.
[16] See, e.g., 'Bookmakers cut Remain odds despite narrow polls', *Financial Times*, May 20, 2016; 'Betting odds tilt towards Brexit', *fastFT*, June 6, 2016.
[17] 'Big London Bets Tilted Bookmakers' 'Brexit' Odds', *Wall Street Journal*, June 26, 2016.

systematically biased the *level* of the implied probability of a leave vote downwards but did not directly affect the information conveyed by *changes* in the probability we use in the estimation of Model (1). Moreover, the betting market in the run-up to the referendum was quite active and deep which made it less prone to potential noise coming from individual bets. Betting on the Brexit referendum outcome broke the U.K. record for non-sporting events, with an estimated GBP 120 million wagered through betting exchanges and bookmaking firms.[18]

[Figure 2 about here]

Furthermore, in what follows, we show how the probability of a Brexit vote moved in response to the news flow, including opinion polls, during the campaign. This indicates that it was not pure noise and contained (or aggregated) economically relevant information. In Figure 2, Panel A, the probability of a Brexit vote is plotted against the Brexit news coverage in the Financial Times. The coverage is calculated as the average number of articles containing the word 'Brexit' over the previous 7 days, searched in the online archives at FT.com. The news coverage proxies for the news flow relevant for updating expectations regarding the outcome of the referendum. After the initial spike following the announcement of the referendum on February 20, the article count went down and started picking up in April when the referendum campaign officially started on April 15. It gradually went up towards the referendum day as the campaign intensified. The behavior of the leave probability is consistent with it being a measure incorporating relevant news. The probability remained stable when the news flow was relatively small, and the daily variation in the probability increased when more news was flowing to the market.

In Panel B of Figure 2, the probability of a Brexit vote is plotted against the percentage-point lead of remain over leave in polls of voting intentions, after excluding 'don't knows'. The data are obtained from whatukthinks.org, a website run by NatCen Social Research. The measure is the so-called poll-of-polls and is calculated as the average of the six most recent poll results available. The plot shows a close link between the two measures, which is particularly strong in the second part of the sample period, with the probability of leave going up (down) when the polls swing against (in favor of) a remain vote. Again, the evidence confirms that the proxy based on bookmakers' odds reflects publicly available information about the prospects of a Brexit vote.

[18] 'Brexit wagers set new record for non-sports bets', *Financial Times*, June 26, 2016.

To further validate the measure of the probability of a leave vote derived from bookmakers' odds, we plot it against the USD/GBP exchange rate (Panel C of Figure 2) sourced from Datastream. *Ex post* we know that the strongest reaction to the referendum outcome was observed on the foreign exchange market. On the announcement of the referendum result on June 24, the pound lost 8.0% against the dollar, compared to a 3.8% drop in the FTSE All Share index. The plot in Panel C of Figure 2 shows a very close link between the value of the pound and the probability of a leave vote, which confirms that the calculated probability contains the same economically relevant information employed by foreign exchange market investors.

Taking all of the above arguments together, we argue that the probability of a Brexit vote calculated from bookmakers' odds is a meaningful measure that contains relevant information despite its systematically biased level and *ex post* incorrect prediction of the outcome of the vote.

3.3 Stock Price Reaction to the Referendum Result

To minimize the concerns that bookmakers' odds were not fully informative, we also use a standard event study approach to estimate firms' Brexit exposures and measure stock price reactions to the referendum result. Given that it has been widely reported that the vote for Brexit came as a surprise, both within and outside the U.K., the referendum result provides a reasonably clean shock that we can use to measure the impact of Brexit on individual companies.

For every firm in our sample we estimate a buy-and-hold return measured over the day of the referendum result (Day 0, June 24, 2016) and the following trading day (Day 1, June 27, 2016):

$$BHR(0,1)_i = \{\prod_{t=0}^{1}(1 + r_{it})\} - 1, \quad (4)$$

where r_{it} is stock i's return on day t. In Section 5 we show robustness of our results to alternative approaches: measuring the stock price reaction on Day 0 only and calculating buy-and-hold abnormal returns using the CAPM or the Fama-French model as benchmarks. As outlined in Section 3.1, political uncertainty associated with Brexit is expected to have a negative impact on stock prices by increasing the risk premium and negatively affecting future cash flows. Where $BHR(0,1)_i$ is more negative, the Brexit exposure is greater.

We use the two measures – the Brexit beta and stock price reaction to the referendum result – as complementary measures to test the robustness of our cross-sectional results. As mentioned above, the event study approach benefits from not relying on Brexit probability

estimated from bookmakers' odds. However, the asset pricing literature (e.g. Fama and French, 1992) shows that firm characteristics which we employ to capture Brexit exposure (most notably size and market-to-book) are typically used to explain the cross-section of stock returns. In an event study approach we hence run the risk of capturing the normal determinants of stock returns and incorrectly interpreting them as determinants of Brexit exposure. In robustness tests in Section 5 we explore alternative ways to estimate the stock price reaction, including the Fama-French approach which explicitly controls for the effect of firm size and market-to-book ratio on stock returns to minimize the risk of incorrect inferences. The Brexit beta introduced in Section 3.1 has the advantage of being unaffected by the average level of stock returns for a firm, which is captured by the model constant (β_{0i}).

3.4 Sample

The sample is constructed in the following way. First, we obtain the list of all stocks listed on the London Stock Exchange (LSE) on January 1, 2016 from the stock exchange website.[19] Only companies incorporated in the United Kingdom with a Premium Listing on the Main Market of the exchange are retained, and the sample further excludes companies in the following sectors (as classified by the LSE): Equity Investment Instruments, Non-Equity Investment Instruments, Real Estate Investment and Services, and Real Estate Investment Trusts. The exclusion is aimed at limiting the sample to operating companies (manufacturers of goods or service providers) for which comparable characteristics can be identified for the cross-sectional analysis. Finally, to be included in the sample, total return data for the stock have to be available in Datastream.

Brexit beta (β_{Bi}), our coefficient of interest in Model (1) might be underestimated for thinly-traded companies (e.g. Dimson, 1979), therefore to avoid biased estimates, we exclude from the final sample the least liquid firms. They are also likely to have the least reliable estimates of $BHR(0,1)_i$, the stock price reaction to the referendum result. We base our illiquidity measure on the frequency of zero returns, as proposed by Lesmond *et al.* (1999), and exclude companies with more than 8 zero returns in the sample period (approximately 10% of days). The final sample contains 331 firms.

[19] http://www.londonstockexchange.com/statistics/historic/company-files/company-files.htm

3.5 Descriptive Statistics of Brexit Exposure Measures

Table 2 presents detailed descriptive statistics of both Brexit exposure measures: Brexit beta (β_{Bi}) in Panel A and the market reaction to the Brexit vote ($BHR(0,1)_i$) in Panel B. The full-sample means and medians of both measures are negative, indicating that in line with theoretical predictions, political uncertainty associated with Brexit has a negative impact on stock returns. The average firm lost 13% of its value when the referendum result was announced (Panel B), and, similarly, in the pre-referendum period, increases in the probability of Brexit led to decreases in stock prices (Panel A).[20] To illustrate the economic significance of Brexit betas, the mean β_{Bi} of -0.025 indicates that when the gap between the probability of a Brexit vote and 0.50 decreased by 13.6% (one standard deviation of x_t) stock prices fell on that day, on average, by 0.34%.[21] For both measures we find large cross-section variation which shows that individual firms are differently exposed to Brexit and it lends support to the main aim of our study.

[Table 2 about here]

The Pearson's (Spearman's rank) correlation coefficient between the two measures in the full sample is 0.297 (0.475), significant at the 1 percent level, indicating that they are positively linked but for various reasons related to the market behavior and measurement of the variables, the relation is not perfect.[22]

To shed light on Brexit exposure across industries, we use the Industry Classification Benchmark (ICB) to split firms into 10 groups. This classification leaves a meaningful number of firms in the majority of industries. Setting aside the Telecommunication and Utilities sectors which are represented by only a handful of firms, for both Brexit exposure measures firms in the Financials, Consumer Goods and Consumer Services sectors are the most exposed to Brexit (have the most negative mean Brexit betas and market reactions), while firms in the Basic Materials and Healthcare sectors are the least exposed.

Financial firms come as the most exposed to political uncertainty associated with Brexit for different possible reasons. First, it is documented that political uncertainty leads to a

[20] The estimated Brexit beta coefficient is negative and statistically different from zero at the 5 percent level in nearly a half (49.2%) of the sample stocks, and it is positive and significant for 3 firms.

[21] $-0.025 \times 0.136 = -0.0034$

[22] The Pearson's correlation coefficient can be influenced by outliers. For the Brexit exposure measures winsorized at the 1st and 99th percentiles, which we use in cross-sectional regressions below to limit the impact of outliers on our results, the correlation coefficient is 0.435. In unreported results we also examine average stock returns around the referendum date for portfolios of stocks formed by reference to their Brexit beta, and this analysis confirms a high degree of correspondence between the two measures of Brexit exposure.

deterioration of economic conditions (e.g. Fernandez-Villaverde *et al.*, 2015; Baker *et al.*, 2016) and, similarly, it was expected that a Brexit vote would have a negative impact on the British economy.[23] In weakening economic conditions profitability of banks and other financials goes down due to reduced demand for new loans and increasing bad debts, and it is further depressed in low interest rate environments expected when economic conditions are weak. Moreover, the high Brexit exposure of financial firms reflects uncertainty about the post-Brexit status of the City of London as a major international financial center. Currently, financial firms located and regulated in the U.K. benefit from passporting rights that allow them to operate freely across the whole European Economic Area. Brexit is expected to bring major disruption in this respect, with uncertainty about future E.E.A. membership. The high exposure of financial firms we find indicates that the stock market investors saw the adverse effect of this uncertainty as more important than the potential benefits of internationalization of British financial firms that could reduce their exposure to domestic risks. Political uncertainty and politically-induced weakening of economic conditions also translate into changes to household disposable income as well as household spending and saving behavior (Giavazzi and McMahon, 2012). Therefore, we see relatively high Brexit exposure among firms in the Consumer Goods and Consumer Services sectors.

Basic Materials and Healthcare firms are least exposed to Brexit-related uncertainty. Many of the firms in these sectors are multinational companies with significant operations or revenues overseas. While they are also potentially negatively affected by the uncertainty of post-Brexit foreign trade agreements, their foreign operations provide diversification of domestic risks (e.g. Shapiro, 1978; Fatemi, 1984; Kwok and Reeb, 2000). It is also possible that they benefit from the weakening pound against other currencies which increases the pound-denominated value of foreign sales or assets. We conduct specific tests to separate diversification benefits from exchange rate benefits in Section 4.3.

Taken together, the results reveal that in the run-up to the referendum stock prices reacted negatively, on average, to the prospect of a Brexit vote, and then they decreased sharply when the U.K. surprisingly voted for Brexit. There was substantial variation in the Brexit exposure of individual sectors. Cross-sectional tests of the determinants of the exposure at the level of the individual firm are presented in Section 4 below.

[23] See, e.g. 'Brexit carries risk of recession, warns Bank of England', *Financial Times*, May 12, 2016; 'IMF chief warns of damage from Brexit vote', *Financial Times*, May 13, 2016.

4. Determinants of Brexit Exposure – Empirical Evidence

4.1. Variables and Regression Specification

Section 2 above discusses theoretical arguments and motivation for cross-sectional determinants of Brexit exposure. Below we present empirical proxies of the determinants used in the regression analysis.

We quantify the firm's internationalization following a similar approach to Garcia and Norli (2012), by counting the number of foreign countries mentioned in the firm's last (2015/2016) annual report published before the Brexit referendum. Annual reports are sourced from Thomson One and firms' websites. Specifically, the foreign country count variable is defined as the natural logarithm of one plus the number of foreign countries mentioned in the report. This measure captures internationalization in a comprehensive manner. In addition to foreign sales, subsidiaries and assets, it picks up, *inter alia*, information on suppliers, new contracts or joint ventures and thereby provides a more complete picture of geographical exposure. To explore geographical diversification in more detail, we use these foreign country count data to separately calculate the European Single Market country count and other country count. As a robustness check we use standard proxies of internationalization i.e. foreign sales measured as the fraction of total sales generated from foreign operations, and foreign assets measured as the fraction of total assets relating to foreign operations.

It is challenging to find good empirical proxies for (unobservable) growth and investment opportunities (Adam and Goyal, 2008) therefore we use several alternative candidates. For all firms in the sample we use the market-to-book (MB) ratio[24] and three-year sales growth. In the subsample of non-financial firms we additionally use capital expenditures (Capex) scaled by the previous year's total assets and research and development (R&D) expenses scaled by total sales as direct measures of investment and development. Missing R&D expenses are set to zero and following the recommendation in Koh and Reeb (2015) we additionally include in regressions an R&D dummy which is equal to one if R&D expenses for the firm are non-missing, and is equal to zero for missing observations.

Firm size is measured as the natural logarithm of the firm's stock market capitalization (in GBP million) sourced from Datastream. Profitability, as a proxy for financial strength, is measured using return on equity (ROE) and is calculated as net income less preferred dividends

[24] Beaulieu *et al.* (2005) argue that firms with low assets in place (proxied by high MB) are less affected by political risks because they can more easily relocate to a lower risk environment. Such an interpretation of the MB ratio gives the opposite prediction regarding the link between Brexit exposure and MB ratio to the one we discuss in Section 2.

divided by the average of current year's and previous year's common equity. Foreign ownership is obtained from Thomson One and is defined as the percentage of shares outstanding held by investors located outside the U.K. E.U. lobbying is measured as the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. Lobbying costs are collected from LobbyFacts.eu. The single market workforce is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. It is calculated based on data pooled from 4 quarterly Labor Force Surveys (LFS) conducted in 2016, available from the Office for National Statistics. Leverage is the ratio of total debt to total assets, and cash holdings is cash scaled by total assets, and both measures are proxies for financial strength and financial constraints. Assets per employee is the natural logarithm of the ratio of total assets to the number of employees. Higher values of the measure reflect lower labor intensity.

Unless stated otherwise, the variables are sourced from Worldscope and are measured at the end of 2015 to avoid the firms' characteristics being influenced by the referendum and the possibility of reverse causality in our empirical setting. Descriptive statistics of explanatory variables are presented in Table 3. In this table and in all subsequent regressions, all variables, both dependent and explanatory, are winsorized at the 1st and 99th percentiles to limit the impact of outliers on estimated coefficients. After excluding firms with missing observations, the largest sample on which regressions are run consists of 297 firms. There is reduced availability of data on foreign sales and foreign assets, and the sample of non-financial firms contains up to 251 firms.

[Table 3 about here]

It is worth noting the high internationalization of U.K. firms. The average sample firm mentions 25 different foreign countries in its annual report (9 in the European Single Market and 16 others), and it generates 46.4% of its sales and holds 28.0% of its assets overseas.

To estimate the determinants of Brexit exposure in the full sample we run the following cross-sectional regression:

$$BrexitExposure_{ij} = \alpha_0 + \alpha_1 LnForeignCountryCount_{ij} + \alpha_2 MBRatio_{ij} + \\ + \alpha_3 SalesGrowth_{ij} + \alpha_4 LnFirmSize_{ij} + \alpha_5 ROE_{ij} + \alpha_6 ForeignOwnership_{ij} + \\ + \alpha_7 EULobbying_{ij} + \alpha_8 SingleMarketWorkforce_{ij} + u_j + \varepsilon_{ij}, \quad (5)$$

where $BrexitExposure_{ij}$ is the Brexit exposure measure for firm i in industry j, and it is either firm i's Brexit beta (β_{Bi}) or its stock price reaction to the Brexit vote ($BHR(0,1)_i$), as defined in Section 3. All independent variables are defined as above.

We run an extended regression for non-financial firms that includes additional independent variables which are either meaningless or not directly comparable for financial firms due to their fundamentally different nature and different reporting requirements (for example, Capex, R&D expenses, labor intensity, leverage or cash holdings):

$$BrexitExposure_{ij} = \alpha_0 + \alpha_1 LnForeignCountryCount_{ij} + \alpha_2 MBRatio_{ij} + \\ + \alpha_3 SalesGrowth_{ij} + \alpha_4 Capex_{ij} + \alpha_5 R\&DExpenses_{ij} + \alpha_6 R\&DDummy_{ij} + \\ + \alpha_7 LnFirmSize_{ij} + \alpha_8 ROE_{ij} + \alpha_9 ForeignOwnership_{ij} + \alpha_{10} EULobbying_{ij} + \\ + \alpha_{11} SingleMarketWorkforce_{ij} + \alpha_{12} Leverage_{ij} + \alpha_{13} CashHoldings_{ij} + \\ + \alpha_{14} LnAssetsPerEmployee_{ij} + u_j + \varepsilon_{ij}. \quad (6)$$

All regressions control for industry fixed effects (u_j) to take into account possible unobservable industry-level factors. Industries are defined according to the Industry Classification Benchmark (ICB). All models are estimated via OLS with heteroskedasticity-consistent standard errors.

4.2. Regression Results

The results of the regression tests are reported in Table 4. As explained in Section 3, Brexit beta (β_{Bi}) and the market reaction to the Brexit vote ($BHR(0,1)_i$) are more negative for firms with higher Brexit exposure, hence variables with a positive (negative) coefficient are associated with reduced (increased) exposure.

[Table 4 about here]

Across all regressions we find strong evidence that internationalization measured with the foreign country count has a moderating effect on Brexit exposure. The coefficients are positive and highly statistically significant indicating that, *ceteris paribus*, stock prices of firms with a larger international exposure decreased less (or even increased) when the probability of a Brexit vote went up, and they had higher (or less negative) returns when the referendum result was announced. The result is consistent with the diversification benefit of international operations. The economic significance of the moderating effect of internationalization is also large. For example, the coefficient of 0.0504 in specification (iii) indicates that a one standard deviation increase in the foreign country count (0.857, as reported in Table 3) is associated

with a 4.3 percentage point higher (less negative) buy-and-hold return. To put this in a perspective, the average buy-and-hold return in the full sample is -13%.

As previously discussed, the positive effect of internationalization could also be driven by the weakening of the GBP associated with Brexit uncertainties. We explore this alternative explanation in detail in Section 4.3 below.

The link between Brexit exposure and growth and investment opportunities is less clear-cut. Across model specifications we find some evidence consistent with our prediction that growth firms are more affected by Brexit-related uncertainties. We find that higher MB ratio firms have lower (more negative) Brexit betas (specifications (i) and (ii)) and firms with higher sales growth have lower (more negative) buy-and-hold returns around the vote result (specifications (iii) and (iv)). However, other proxies for firm growth (Capex and R&D expenses) are insignificant, while in specification (iv) we somewhat surprisingly find that firms with non-missing R&D expenses are less exposed to Brexit uncertainties (the coefficient is positive indicating a less negative market reaction to Brexit).[25] Given that the results depend on the model specification and the proxy used, we conclude that while our evidence is indicative, we are not able to draw firm conclusions about the link between Brexit exposure and growth opportunities.

Among the control variables, as indicated above, we find that larger firms are more affected by Brexit as the coefficients of firm size are negative and highly significant across all model specifications. This result is consistent with theoretical predictions in Pastor and Veronesi (2012) and with the political cost hypothesis of Zimmerman (1983). The result is potentially important for the stock market as a whole, given the significance of large-cap firms for broad stock market indices. We also find a moderating effect of higher profitability (ROE) on Brexit beta. We do not find any statistically significant relation between exposure to Brexit-related uncertainty and other control variables which might indicate that the market does not see them as relevant factors in pricing the impact of Brexit.

To summarize the results related to our key variables of interest, the regression analysis reveals that, *ceteris paribus*, more internationalized firms are less exposed to Brexit-related political uncertainty, and there is some evidence of higher Brexit exposure of high-growth

[25] We use R&D expenses as a proxy for growth opportunities. However, the literature provides also an alternative view on the link between political uncertainty and R&D spending which can explain our empirical finding. Berk *et al.* (2004) show that R&D expenses, due to their nature, can be seen as a compound option on systematic uncertainty. Atanassov *et al.* (2018) build on this insight and argue that, as a result, higher political uncertainty increases the value of R&D investment. This can explain why we find some evidence that the value of firms with non-zero R&D expenses decreased less compared to firms without R&D expenses in response to the Brexit vote.

firms. To outline in a graphical form the effect of internationalization, the most robust determinant of Brexit exposure in our tests, Figure 3 presents the performance of equally-weighted portfolios formed on the basis of the foreign country count around the referendum result date. The portfolio of firms in the bottom quartile of internationalization (Q1) is clearly the most affected by the Brexit vote, while the effect of Brexit on the portfolio of firms in the top quartile of internationalization (Q4), is limited.

[Figure 3 about here]

4.3. Sources of Benefits of Internationalization

As reported in Section 4.2, we find strong and robust evidence that firms with a larger international exposure are less affected by Brexit uncertainty. The result is consistent with the diversification benefits of internationalization but could also be driven by exchange rate effects. In this subsection, we develop supplementary tests to shed more light on these two interpretations.

To test if the benefit of internationalization is driven purely by the weakening of the pound associated with Brexit, we first re-estimate the Brexit beta controlling for the foreign exchange exposure of each firm. The underlying idea is to split the sensitivity to Brexit uncertainties into the sensitivity to exchange rate changes and the sensitivity to Brexit uncertainties net of the exchange rate effect. Specifically, we re-run Model (1) controlling for changes in the GBP/USD exchange rate, in the spirit of Jorion (1990):

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{xi} r_t^{GBPUSD} + \varepsilon_{it}, \quad (7)$$

where r_t^{GBPUSD} is the percentage change in the GBP/USD exchange rate on day *t*, and all other notation is as before. In this extended model, β_{xi} captures the effect of foreign exchange rate movements on stock returns, leaving β_{Bi} to capture the effect of Brexit-related uncertainties net of currency effects. Hence, if internationalization affects Brexit beta through the exchange rate channel only, we should see no link between internationalization and Brexit beta estimated from Model (7) after allowing for exchange rate effects. We then re-run baseline regressions using β_{Bi}'s estimated from Model (7) as the dependent variable. The results of the estimation are reported in columns (i) and (ii) of Table 5.

[Table 5 about here]

The results clearly confirm the strong and robust link between Brexit beta and foreign diversification. The coefficients of the foreign country count variable across both specifications

are positive and highly significant, with even larger magnitudes than in the baseline tests reported in Table 4. Therefore, we conclude that the moderating impact of foreign activities on Brexit exposure is not driven by currency movements and is consistent with the diversification benefits of internationalization which reduces the exposure of firms to domestic political uncertainty.

We also re-estimate regressions (5) and (6) substituting the foreign country count with the separately calculated European (specifically, European Single Market) country count and other country count. If our key result is driven by diversification benefits, we should find a stronger impact for non-European exposure. Brexit uncertainties are likely to affect the rest of Europe, at least to some extent, and thus European operations are expected to provide a weaker diversification mechanism of the Brexit exposure of U.K. firms. The results of the new regressions are reported in columns (iii) to (vi) of Table 5. We find that the coefficient of the non-European country count is larger in magnitude and, unlike the coefficient of the European country count, is statistically significant, consistent with our prediction. However, the F-test for differences between the two coefficients is significant only for regressions with $BHR(0,1)_i$ as the dependent variable (columns (v) and (vi)). Nevertheless, the evidence confirms our diversification argument as we find that the effect of foreign activities is driven by global activities beyond Europe where the diversification benefits are likely to be strongest.

4.4. Alternative Measures of Internationalization

In the main tests of this paper a firm's internationalization is proxied with the number of countries mentioned in its annual report. This measure has the benefit of capturing different aspects of internationalization – sales in foreign markets, foreign subsidiaries or offices, international supply chains or new international contracts. It also has the benefit of being available for each firm. In this section we check the robustness of our conclusions regarding the impact of internationalization on Brexit exposure employing reported foreign sales or foreign assets, which capture foreign activities in a more focused way.[26] The results of re-estimated baseline regressions are reported in Table 6.

[Table 6 about here]

[26] We do not include the foreign country count and foreign sales or assets together in a regression because they are highly correlated. The correlation between the foreign country count and foreign sales is 0.610, and between the foreign country count and foreign assets it is 0.522. The correlation between foreign sales and assets is 0.723.

Across all model specifications the coefficient of foreign sales is positive and statistically significant. The coefficient of foreign assets is positive and highly significant where $BHR(0,1)_i$ is the dependent variable (specifications (vii) and (viii)) and is positive but insignificant in regressions where β_{Bi} is the dependent variable (specifications (iii) and (iv)). Overall, the tests confirm our key finding of the moderating impact of foreign activities on Brexit exposure.[27]

These additional tests suggest that the benefits of international diversification arise from outputs sold into foreign markets (i.e. the international diversification of the revenue base) and probably also from diversification of inputs (i.e. the international diversification of the cost base). Reported foreign sales directly measure international diversification of the revenue base. Foreign assets can be used as a proxy for international diversification of inputs, based on the assumption that firms choose an international location of operations (assets) to benefit from access to foreign labor, materials or other production inputs, however the proxy is weaker in this case since complete data on international diversification of the cost base is not available at the firm level.[28]

5. Further Tests and Robustness Checks

5.1. Alternative Estimation of Brexit Betas

In this section we explore alternative methods of estimating Brexit betas. We start by re-estimating Model (1) with an alternative definition of x_t. In the first revised estimation we define x_t as a raw (not scaled) change in the probability of Brexit ('Change in Probability (Not Scaled)' reported in Table 1):

$$x_t = prob_t^{Leave} - prob_{t-1}^{Leave}. \quad (8)$$

This approach makes a simplifying assumption that the market reaction to the change in the probability of a leave vote does not depend on how close the probability is to the 50/50 split, but at the same time it makes the interpretation of β_{Bi} more straightforward. In the revised approach β_{Bi} directly measures the market assessment of the value effect of Brexit, defined as

[27] Because the value of foreign sales or foreign assets is directly affected by the exchange rate, in unreported tests we also test the link between foreign sales or assets and the Brexit beta net of currency effects estimated from Model (7). Coefficients of both foreign sales and foreign assets are positive and statistically significant in all specifications.

[28] For example, firms do not report data on imports used in production. Sourcing strategies as well as integration strategies of multinational firms are very complex (Helpman, 2006), therefore any conclusions related to inputs have to be drawn with caution.

the stock return associated with a hypothetical change in the probability of a leave vote from 0 to 1.

Second, we re-run Model (1) defining x_t as the daily percentage change in the probability of a leave vote ('Change in Probability Scaled by Lagged Probability' reported in Table 1):

$$x_t = \frac{prob_t^{Leave} - prob_{t-1}^{Leave}}{prob_{t-1}^{Leave}}. \quad (9)$$

Third, we re-run Model (1) by adding a lagged change in the probability of a Brexit vote, x_{t-1}:

$$r_{it} = \beta_{0i} + \beta_{B1i} x_t + \beta_{B2i} x_{t-1} + \varepsilon_{it}, \quad (10)$$

with x_t defined as in the baseline tests (Equation (2)). Brexit exposure is then calculated as the sum of the coefficients of the contemporaneous and lagged x ($\beta_{B1i} + \beta_{B2i}$). This approach takes into account the possibility of Brexit related news arriving late in the day, moving bookmakers' odds after stock exchange trading hours[29] and therefore being incorporated into stock prices the following day.

Fourth, we re-estimate the Brexit beta controlling for market-wide factors captured by the return on the FTSE All Share index:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{mi} r_t^{FTSE} + \varepsilon_{it}, \quad (11)$$

where x_t is defined as in the baseline tests (Equation (2)) and r_t^{FTSE} is the return on the FTSE All Share index on day t. Adding the market return changes the interpretation of a firm's Brexit beta (β_{Bi}) given that the FTSE index is itself expected to be affected by Brexit-related uncertainties. β_{Bi} in Model (11) measures the firm-specific, residual Brexit exposure not captured by Brexit exposure of the whole market and hence is not directly comparable to magnitudes of Brexit betas estimated in the baseline Model (1).

To move closer to measuring the full Brexit exposure of each firm but still controlling for broad macro-level developments, including general economic uncertainty, we re-run Model (1) controlling for S&P500 returns and changes in the VIX index which are less likely to be affected by the changing probability of Brexit:

$$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{S\&P500} + \beta_{m2i} r_{t-1}^{S\&P500} + \beta_{v1i} \Delta VIX_t + \beta_{v2i} \Delta VIX_{t-1} + \varepsilon_{it}, \quad (12)$$

where $r_t^{S\&P500}$ is the return on the S&P500 index on day t and ΔVIX_t is the change in the value of the VIX index on day t. All other notation is as before. Due to non-overlapping trading hours between the U.K. and the U.S. – markets in the U.S. close later than in the U.K. – the model

[29] We do not have time-stamped changes in odds, we only have data on end-of-day (11:59pm) prevailing odds.

includes both day *t*'s and *t-1*'s S&P500 returns and changes in the VIX. The model allows us to isolate the effect of Brexit over and above other market-wide factors. Data on the FTSE All Share, S&P500 and VIX indices are from Datastream.

5.2. Alternative Estimation of the Stock Price Reaction to the Referendum Result

We also test the robustness of our results to different methods of measuring the stock price reaction to the referendum outcome. First, we measure the stock price reaction as a one-day stock return on June 24 , the day the referendum result was announced (Day 0). Second, we calculate buy-and-hold *abnormal* returns over the two-day event window (Day 0, June 24; Day 1, June 27) as follows:

$$BHAR(0,1)_i = \{\prod_{t=0}^{1}(1 + r_{it})\} - \{\prod_{t=0}^{1}(1 + r_{bit})\}, \quad (13)$$

where r_{it} is stock *i*'s actual return and r_{bit} is stock *i*'s benchmark return on day *t*. The benchmark returns (r_{bi}) for each day are calculated by reference to the Capital Asset Pricing Model (CAPM), or, alternatively, the Fama-French three factor model:

$$r_{bit} = r_{it}^{CAPM} = r_{ft} + \beta_{mi}(r_{mt} - r_{ft}), \quad (14)$$

$$r_{bit} = r_{it}^{FF} = r_{ft} + \beta_{mi}(r_{mt} - r_{ft}) + \beta_{si}SMB_t + \beta_{vi}HML_t, \quad (15)$$

where the risk-free rate (r_{ft}) is the return on three-month U.K. Treasury bills and the market return (r_{mt}) is the return on the FTSE All Share Index on day *t*. The returns are obtained from Datastream. SMB_t and HML_t are day *t*'s returns on the size and value factor portfolios respectively, the calculation of which is set out in Gregory *et al.* (2013). The daily returns to the factor portfolios are made available by Gregory *et al.*[30] Stock *i*'s market beta in the CAPM model (β_{mi}) and the betas in the Fama-French model (β_{mi}, β_{si}, β_{vi}) are calculated employing daily returns for the pre-referendum period from January 1, 2015 to December 31, 2015.

Buy-and-hold abnormal returns ($BHAR(0,1)_i$) calculated from Model (13) control for each firm's exposure to market movements and size and value factors which have been employed to determine the cross-section of stock returns. A stock's buy-and-hold abnormal return measures the firm specific price reaction to Brexit not captured by the market-wide reaction. As above, the magnitude of $BHAR(0,1)_i$ is not directly comparable to the magnitude of the buy-and-hold (unadjusted) returns used as the measure of Brexit exposure in the baseline tests.

[30] http://business-school.exeter.ac.uk/research/centres/xfi/famafrench/

5.3. Descriptive Statistics and Regressions for Alternative Brexit Exposure Measures

Descriptive statistics of the Brexit exposure measures estimated using the alternative methods are presented in Table 7.

[Table 7 about here]

All results confirm a large cross-sectional dispersion of the estimated Brexit exposure. As expected, the methods that control for market-wide movements (rows (iv), (vii) and (viii)) have mean estimates lower in absolute magnitudes than baseline estimates reported in Table 2.

The calculation based on the raw change in the probability of a leave vote (row (i)) yields the mean coefficient of -0.164 which indicates that the market priced the total impact of Brexit, on average, as a reduction in value of 16.4%. The result is in line with the results of the event study presented in Table 2 where the average buy-and-hold return in reaction to the referendum result is -13.0%. Assuming that the market priced a non-zero probability of a Brexit vote shortly before the referendum - the probability of a leave vote implied form bookmakers odds was 0.245 the day before the referendum - the reaction observed is the price adjustment to the referendum outcome. If, for simplicity, we assume that the scenario of no-Brexit is value neutral, and the scenario of Brexit leads to a value decrease of 16.4% (as estimated above), an increase in the probability of Brexit from 0.245 to 1 (the confirmed referendum result) leads to a price adjustment of 12.4%, very close to the mean buy-and-hold return of 13.0%.[31] Again, this result confirms that the two broad alternative approaches to measure Brexit exposure used in this study (Brexit beta and the stock price reaction to the Brexit vote) present a consistent picture.

When we estimate Brexit exposure including the lagged change in the probability of a Brexit vote (Model (10) above, with the estimates presented in row (iii) of Table 7) the magnitude of the mean exposure measure increases slightly from -0.025 in baseline tests to -0.030 in the revised tests. Overall however, we find that the potential problems of non-synchronous measurement of returns and changes in bookmakers' odds is limited; the coefficient of the lagged change in Brexit probability, β_{B2i} in Model (10), is significant at the 5 percent level for only 15 firms (there are 11 negative and 4 positive coefficients; results are not tabulated).

[31] (1 - 0.245) × -0.164 = -0.124

Regression results with alternative estimates of the Brexit beta as the dependent variable are presented in Table 8, and the results for alternative estimates of the stock price reaction to the Brexit vote are presented in Table 9.

[Tables 8 and 9 about here]

Across all model specifications in both tables we confirm that internationalization has a moderating impact on Brexit exposure. This result is very robust and highly statistically significant. We also confirm our baseline results for the link between Brexit exposure and growth opportunities – the results indicate that high-growth firms are more exposed but the significance of specific measures of growth (MB ratio or sales growth) varies across regression models. Also, the results for control variables are broadly in line with the main results presented in Table 4.

In sum, the different approaches to measuring Brexit exposure summarized in Table 7 above reveal the same cross-sectional regularities, confirming the robustness of key findings of this paper.

6. Conclusions

This paper examines the firm-level determinants of British public companies' exposure to Brexit, an unprecedented political event which substantially increased political uncertainty. On June 23, 2016 the U.K. voted to leave the E.U. with far-reaching consequences affecting virtually all government policies. This paper contributes to the literature by providing an analysis of the determinants of exposure to uncertainty associated with a major political event at the firm level. As such, it provides important evidence relevant to the current situation around the globe where policy uncertainty is at a record high (Davis, 2016).

We estimate each firm's Brexit exposure in two alternative ways: as sensitivity of its stock returns to changes in the probability of a Brexit vote calculated from bookmakers' odds during the referendum campaign, and as its stock price reaction to the referendum result.

We develop our predictions on the determinants of Brexit exposure based on the existing literature on policy and political uncertainty and we focus on two firm characteristics: internationalization and growth and investment opportunities. *Ex ante* we propose contrary arguments which indicate that international operations might either reduce or increase exposure to Brexit. Our cross-sectional regressions provide strong and robust evidence that firms with greater international diversification, particularly outside the European Single Market, have a lower Brexit exposure. We show that the effect of foreign operations is not a pure exchange

rate effect (due to the weakening of the British pound) and we suggest that the moderating impact of foreign operations on the exposure to political uncertainty associated with Brexit results from multinational firms being able to diversify domestic policy risks. The evidence regarding growth and investment opportunities is less conclusive but we find some suggestive evidence that high-growth firms are more exposed to Brexit uncertainties. At the industry level, we find that Financials and companies in the Consumer Goods and Consumer Services sectors are most affected by uncertainties associated with Brexit.

Our analysis is based on stock market data around the Brexit referendum. Follow-on research could provide further evidence on how individual companies are affected by Brexit-related uncertainty when financial reporting data become available in the post-Brexit period.

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Appendix A. Glossary of Terms Relating to Political and Economic Arrangements in Europe

Name / Organization	Member countries
European Union (E.U.)	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom
European Economic Area (E.E.A.)	E.U. plus Iceland, Liechtenstein and Norway
European Single Market	E.E.A. plus Switzerland

Table 1. Implied Probability of Leave (Brexit) Vote

	Mean	Std dev	Min	Q1	Median	Q3	Max
Probability of Leave (Brexit) Vote	0.293	0.043	0.179	0.271	0.294	0.325	0.392
Gap between Probability and 0.50	0.207	0.043	0.108	0.175	0.206	0.229	0.321
Change in Probability (Not Scaled)	-0.001	0.022	-0.134	-0.006	0.000	0.004	0.073
Change in Probability Scaled by Lagged Gap	-0.012	0.136	-1.009	-0.030	0.000	0.021	0.323
Change in Probability Scaled by Lagged Probability	-0.001	0.072	-0.365	-0.021	0.000	0.014	0.269

Probability of Leave (Brexit) Vote is the average implied probability from odds by Coral, Ladbrokes, Paddy Power and William Hill, with probabilities for individual bookmakers calculated as:

$prob_{jt}^{Leave} = \frac{1/odds_{jt}^{Leave}}{1/odds_{jt}^{Leave}+1/odds_{jt}^{Remain}}$,

where $odds_{jt}^{Leave}$ ($odds_{jt}^{Remain}$) is the end of day *t* decimal odds offered by bookmaker *j* on the leave (remain) outcome of the referendum. *Change in Probability Scaled by Lagged Gap* (variable x_t in subsequent tests, unless stated otherwise) is calculated as:

$x_t = \frac{prob_t^{Leave}-prob_{t-1}^{Leave}}{0.5-prob_{t-1}^{Leave}}$,

where $prob_t^{Leave}$ is the *Probability of Leave Vote* defined above. *Change in Probability Scaled by Lagged Probability* is the percentage change in the *Probability of Leave Vote* and is calculated as:

$\frac{prob_t^{Leave}-prob_{t-1}^{Leave}}{prob_{t-1}^{Leave}}$.

All variables are measured for 84 trading days between February 20, 2016, when the E.U. membership referendum was announced and June 22, 2016, one day before the referendum. Data on odds are sourced from Oddschecker.

Table 2. Brexit Beta and Market Reaction to Brexit Vote

	N	Mean	Std dev	Min	Q1	Median	Q3	Max
Panel A: Brexit Beta (β_{Bi})								
Full Sample	331	-0.025	0.035	-0.120	-0.040	-0.027	-0.014	0.431
Basic Materials	22	-0.010	0.034	-0.100	-0.021	-0.014	0.001	0.094
Consumer Goods	34	-0.033	0.020	-0.072	-0.052	-0.029	-0.019	0.001
Consumer Services	82	-0.028	0.023	-0.080	-0.044	-0.029	-0.016	0.040
Financials	49	-0.040	0.020	-0.120	-0.050	-0.040	-0.029	0.014
Healthcare	16	0.012	0.113	-0.036	-0.026	-0.016	-0.005	0.431
Industrials	90	-0.020	0.024	-0.059	-0.034	-0.021	-0.010	0.085
Oil & Gas	11	-0.026	0.027	-0.099	-0.033	-0.015	-0.011	-0.006
Technology	15	-0.024	0.023	-0.062	-0.040	-0.026	0.005	0.009
Telecommunication	5	-0.036	0.014	-0.055	-0.041	-0.039	-0.028	-0.018
Utilities	7	-0.033	0.010	-0.048	-0.040	-0.034	-0.025	-0.018
Panel B: Market Reaction to Brexit Vote (BHR(0,1)$_i$)								
Full Sample	331	-0.130	0.108	-0.471	-0.197	-0.116	-0.063	0.287
Basic Materials	22	-0.027	0.123	-0.169	-0.095	-0.064	-0.028	0.287
Consumer Goods	34	-0.149	0.154	-0.410	-0.310	-0.107	-0.028	0.044
Consumer Services	82	-0.148	0.084	-0.366	-0.209	-0.154	-0.092	0.038
Financials	49	-0.199	0.108	-0.471	-0.246	-0.187	-0.123	-0.031
Healthcare	16	-0.045	0.080	-0.233	-0.083	-0.030	0.005	0.058
Industrials	90	-0.126	0.085	-0.355	-0.163	-0.103	-0.068	0.012
Oil & Gas	11	-0.067	0.060	-0.153	-0.124	-0.066	-0.037	0.030
Technology	15	-0.125	0.088	-0.303	-0.201	-0.115	-0.080	0.009
Telecommunication	5	-0.097	0.042	-0.145	-0.116	-0.114	-0.069	-0.039
Utilities	7	-0.045	0.057	-0.117	-0.107	-0.021	0.006	0.018

Panel A of this table presents descriptive statistics for β_{Bi}, the Brexit betas of individual firms, estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,

where r_{it} is stock i's return on day t and x_t is the scaled change in the probability of a Brexit vote on day t implied by bookmakers' odds. β_{Bi} is negative where firm stock returns fall in response to an increase in the probability of a Brexit vote. The model is estimated over 84 trading days between February 20, 2016 and June 22, 2016. Panel B presents descriptive statistics for individual firms' stock price reaction to the Brexit vote. It is measured as the stock buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016). The sample includes all U.K. firms listed on the London Stock Exchange on January 1, 2016, excluding Equity Investment Instruments, Non-Equity Investment Instruments, Real Estate Investment and Services, Real Estate Investment Trusts and the least liquid firms (firms with more than 8 zero daily returns between February 20, 2016 and June 22, 2016). Industries are defined according to the Industry Classification Benchmark (ICB).

Table 3. Descriptive Statistics of Independent Variables

	N	Mean	Std dev	Min	Q1	Median	Q3	Max
Panel A: Measures of Internationalization								
Ln Foreign Country Count	297	2.901	0.857	1.099	2.197	2.996	3.497	4.736
Europe	297	2.004	0.794	0.000	1.386	2.079	2.639	3.367
Other	297	2.420	0.904	0.693	1.792	2.485	2.996	4.431
Foreign Country Count (raw)	297	25	22	2	8	19	32	113
Europe (raw)	297	9	7	0	3	7	13	28
Other (raw)	297	16	16	1	5	11	19	83
Foreign Sales	277	0.464	0.363	0.000	0.037	0.504	0.811	1.000
Foreign Assets	231	0.280	0.286	0.000	0.000	0.199	0.542	0.992
Panel B: Growth and Investment Opportunities								
MB Ratio	297	3.959	4.521	0.090	1.590	2.670	4.370	33.950
Sales Growth	297	0.052	0.161	-0.288	-0.027	0.030	0.096	0.910
Capex	251	0.049	0.043	0.000	0.017	0.037	0.064	0.185
R&D Expenses	251	0.023	0.084	0.000	0.000	0.000	0.008	0.700
R&D Dummy	251	0.406	0.492	0.000	0.000	0.000	1.000	1.000
Panel C: Other Variables / Control Variables								
Ln Firm Size	297	7.362	1.509	3.781	6.370	7.198	8.327	11.096
Firm Size (GBP mil)	297	5,550	12,337	44	584	1,337	4,135	65,930
ROE	297	0.153	0.372	-0.852	0.043	0.130	0.213	2.245
Foreign Ownership	297	0.308	0.185	0.021	0.175	0.286	0.424	0.841
E.U. Lobbying	297	0.001	0.002	0.000	0.000	0.000	0.000	0.013
Single Market Workforce	297	0.076	0.044	0.019	0.051	0.064	0.100	0.314
Leverage	251	0.229	0.172	0.000	0.091	0.217	0.332	0.855
Cash Holdings	251	0.082	0.082	0.000	0.028	0.059	0.100	0.492
Ln Assets per Employee	251	-1.524	1.165	-4.075	-2.293	-1.630	-0.936	3.719
Assets per Employee (GBP mil)	251	0.604	2.698	0.017	0.101	0.196	0.392	41.235

This table presents descriptive statistics for the independent variables used in cross-sectional regressions employed to determine the Brexit exposure of individual firms. *Ln Foreign Country Count* is the natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. The foreign countries are further split into European Single Market countries ('Europe') and other foreign countries. *Foreign Sales* is sales generated from foreign operations divided by total sales. *Foreign Assets* is assets of foreign operations divided by total assets. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Ln Assets per Employee* is the natural logarithm of the ratio of total assets to the number of employees. All variables are winsorized at the 1st and 99th percentile. The sample is limited to companies with all data available (297 for all firms including financial firms, and 251 for non-financial firms), except for *Foreign Sales* and *Foreign Assets* for which the availability is lower.

Table 4. Determinants of Brexit Exposure

	Dependent Variable: Brexit Beta (β_{Bi})		Dependent Variable: Market Reaction to Brexit Vote ($BHR(0,1)_i$)	
	(i)	(ii)	(iii)	(iv)
Ln Foreign Country Count	0.0049***	0.0043**	0.0504***	0.0458***
	(2.74)	(2.11)	(6.03)	(4.92)
MB Ratio	-0.0008**	-0.0007*	0.0000	-0.0013
	(-2.22)	(-1.70)	(0.03)	(-0.88)
Sales Growth	-0.0015	-0.0099	-0.1270***	-0.0909**
	(-0.15)	(-1.16)	(-3.20)	(-1.99)
Capex		0.0409		-0.0179
		(0.93)		(-0.12)
R&D Expenses		0.0070		-0.0359
		(0.44)		(-0.51)
R&D Dummy		0.0040		0.0345***
		(1.16)		(2.93)
Ln Firm Size	-0.0052***	-0.0063***	-0.0109**	-0.0127***
	(-5.08)	(-5.05)	(-2.57)	(-2.65)
ROE	0.0152***	0.0157***	0.0032	0.0117
	(3.41)	(3.23)	(0.24)	(0.88)
Foreign Ownership	0.0014	0.0070	0.0121	0.0351
	(0.19)	(0.94)	(0.38)	(1.06)
E.U. Lobbying	0.2283	0.9795	1.5760	4.7482
	(0.42)	(1.31)	(0.73)	(1.38)
Single Market Workforce	0.0373	0.0329	0.0169	-0.0241
	(1.39)	(1.13)	(0.13)	(-0.20)
Leverage		-0.0087		0.0512
		(-0.83)		(1.32)
Cash Holdings		-0.0247		-0.0345
		(-1.38)		(-0.48)
Ln Assets per Employee		0.0009		-0.0003
		(0.59)		(-0.06)
Constant	0.0016	0.0099	-0.0661	-0.0930**
	(0.19)	(0.96)	(-1.53)	(-2.15)
Industry Dummies	Yes	Yes	Yes	Yes
Number of Observations	297	251	297	251
Adjusted R-squared	0.1717	0.1443	0.3344	0.3158

This table presents estimated coefficients from regressions of Brexit exposure on a set of firm characteristics. Brexit exposure is measured alternatively as the Brexit beta or the stock price reaction to the Brexit vote.
Brexit beta (β_{Bi}) is estimated from the model:
$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,
where r_{it} is stock i's return on day t and x_t is the scaled change in the probability of a Brexit vote on day t implied by bookmakers' odds. B_{Bi} is negative where firm returns fall in response to an increase in the probability of a Brexit vote. The model is estimated over 84 trading days between February 20, 2016 and June 22, 2016.
The stock price reaction to the Brexit vote ($BHR(0,1)_i$) is measured as the buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016).
The independent variables relate to firm characteristics and are: *Ln Foreign Country Count* is the natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total

(continued)

Table 4. – *continued*

assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Assets per employee* is the natural logarithm of the ratio of total assets to the number of employees. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively. Regressions (ii) and (iv) are run for non-financial firms only and hence have a smaller number of observations.

Table 5. Sources of Benefits of Internationalization

	Dependent Variable: Brexit Beta (β_{Bi}) Controlling for FX Exposure		Dependent Variable: Brexit Beta (β_{Bi})		Dependent Variable: Market Reaction to Brexit Vote ($BHR(0,1)_i$)	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Ln Foreign Country Count	0.0062***	0.0061***				
	(3.67)	(3.01)				
Ln Foreign Country Count - Europe			-0.0001	0.0003	-0.0025	-0.0019
			(-0.06)	(0.09)	(-0.28)	(-0.20)
Ln Foreign Country Count - Other			0.0052***	0.0042*	0.0537***	0.0479***
			(2.65)	(1.94)	(6.09)	(4.96)
MB Ratio	-0.0010**	-0.0011***	-0.0008**	-0.0007*	0.0002	-0.0011
	(-2.54)	(-2.61)	(-2.19)	(-1.65)	(0.12)	(-0.73)
Sales Growth	0.0038	-0.0008	-0.0006	-0.0089	-0.1190***	-0.0801*
	(0.41)	(-0.09)	(-0.06)	(-1.08)	(-2.99)	(-1.81)
Capex		0.0662		0.0403		-0.0267
		(1.41)		(0.92)		(-0.18)
R&D Expenses		0.0177		0.0073		-0.0300
		(1.00)		(0.46)		(-0.43)
R&D Dummy		0.0031		0.0036		0.0347**
		(0.92)		(1.02)		(2.57)
Ln Firm Size	-0.0057***	-0.0066***	-0.0052***	-0.0063***	-0.0110***	-0.0121***
	(-5.71)	(-5.51)	(-5.08)	(-4.96)	(-2.67)	(-2.58)
ROE	0.0145***	0.0156***	0.0152***	0.0156***	0.0028	0.0105
	(2.74)	(3.09)	(3.38)	(3.19)	(0.21)	(0.78)
Foreign Ownership	0.0069	0.0108	0.0013	0.0071	0.0122	0.0366
	(0.88)	(1.34)	(0.18)	(0.95)	(0.38)	(1.12)
E.U. Lobbying	0.3443	1.0083	0.2269	0.9644	1.6443	4.5881
	(0.77)	(1.17)	(0.43)	(1.34)	(0.81)	(1.40)
Single Market Workforce	0.0596**	0.0533*	0.0348	0.0321	-0.0096	-0.0339
	(2.44)	(1.93)	(1.30)	(1.10)	(-0.07)	(-0.27)
Leverage		-0.0063		-0.0094		0.0430
		(-0.65)		(-0.88)		(1.09)
Cash Holdings		-0.0120		-0.0245		-0.0318
		(-0.60)		(-1.37)		(-0.45)
Ln Assets per Employee		0.0013		0.0008		-0.0015
		(0.79)		(0.53)		(-0.26)
Constant	0.0133	0.0175*	0.0047	0.0127	-0.0348	-0.0623
	(1.62)	(1.72)	(0.55)	(1.24)	(-0.88)	(-1.53)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	297	251	297	251	297	251
Adjusted R-squared	0.2483	0.2528	0.1733	0.1424	0.3506	0.3261
Europe = Other (F-test)			1.95	0.85	13.27***	8.84***

This table presents estimated coefficients from regressions of Brexit exposure on a set of firm characteristics. In the specifications in columns (i) and (ii) our dependent variable is measured after controlling for exchange rate movements, and in the specifications in columns (iii) through (vi) we include a refinement to a key independent variable, the foreign country count measure.

Brexit exposure is measured alternatively as the Brexit beta or the stock price reaction to the Brexit vote.

In columns (i) and (ii), Brexit beta (β_{Bi}) is estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{xi} r_t^{GBPUSD} + \varepsilon_{it}$,

(continued)

Table 5. – *continued*

where r_{it} and x_t are defined as above, and r_t^{GBPUSD} is the percentage change in the GBP/USD exchange rate on day *t*.

In columns (ii) and (iii), Brexit beta (β_{Bi}) is estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,

where r_{it} is stock *i*'s return on day *t* and x_t is the scaled change in the probability of a Brexit vote on day *t* implied by bookmakers' odds. The model is estimated over 84 trading days between February 20, 2016 and June 22, 2016. In columns (v) and (vi), the stock price reaction to the Brexit vote ($BHR(0,1)_i$) is measured as the buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016).

The independent variables relate to firm characteristics and are: *Ln Foreign country count* is the natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. In columns (iii)-(vi) the foreign countries are split into European Single Market countries ('Europe') and other foreign countries. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Ln Assets per Employee* is the natural logarithm of the ratio of total assets to the number of employees. All dependent and independent variables are winsorized at the 1st and 99th percentile. *T*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. The bottom row of the table reports *F*-statistics of the test for equality of coefficients of *Ln Foreign country count – Europe* and *Ln Foreign country count – other*. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively. Regressions (ii), (iv) and (vi) are run for non-financial firms only.

Table 6. Determinants of Brexit Exposure – Alternative Measures of Internationalization

	Dependent Variable: Brexit Beta (β_{Bi})				Dependent Variable: Market Reaction to Brexit Vote ($BHR(0,1)_i$)			
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
Foreign Sales	0.0086**	0.0082*			0.1073***	0.0907***		
	(2.13)	(1.81)			(6.31)	(4.69)		
Foreign Assets			0.0061	0.0076			0.0747***	0.0763***
			(1.16)	(1.27)			(3.13)	(3.00)
MB Ratio	-0.0008**	-0.0009**	-0.0011**	-0.0013**	0.0009	-0.0011	0.0006	-0.0014
	(-2.15)	(-2.00)	(-2.04)	(-1.98)	(0.77)	(-0.89)	(0.35)	(-0.78)
Sales Growth	-0.0102	-0.0141	-0.0176*	-0.0230**	-0.1801***	-0.1600***	-0.2136***	-0.1923***
	(-1.22)	(-1.39)	(-1.86)	(-2.22)	(-4.48)	(-3.41)	(-4.28)	(-3.59)
Capex		0.0258		0.0142		0.0247		0.1042
		(0.63)		(0.30)		(0.15)		(0.58)
R&D Expenses		0.0091		-0.0603***		-0.0045		0.0189
		(0.61)		(-2.18)		(-0.09)		(0.11)
R&D Dummy		0.0042		0.0064		0.0317**		0.0409***
		(1.15)		(1.43)		(2.37)		(2.69)
Ln Firm size	-0.0043***	-0.0053***	-0.0044***	-0.0052***	-0.0010	-0.0016	-0.0011	-0.0012
	(-4.42)	(-4.62)	(-3.97)	(-4.12)	(-0.27)	(-0.40)	(-0.25)	(-0.26)
ROE	0.0159***	0.0173***	0.0212***	0.0245***	-0.0063	0.0076	-0.0097	-0.0000
	(3.44)	(3.47)	(2.78)	(2.88)	(-0.47)	(0.57)	(-0.45)	(-0.00)
Foreign Ownership	0.0043	0.0075	0.0104	0.0153*	0.0279	0.0358	0.0516	0.0430
	(0.61)	(0.96)	(1.26)	(1.67)	(0.92)	(1.10)	(1.50)	(1.15)
E.U. Lobbying	0.2386	1.1388	0.3658	1.3832*	1.0159	6.9909*	3.0961	9.8679**
	(0.44)	(1.50)	(0.58)	(1.79)	(0.45)	(1.95)	(1.05)	(2.40)
Single Market Workforce	0.0281	0.0176	0.0394	0.0263	-0.1410	-0.2260	-0.0245	-0.1359
	(1.07)	(0.62)	(1.32)	(0.86)	(-0.97)	(-1.61)	(-0.17)	(-0.99)
Leverage		-0.0072		-0.0045		0.0380		0.0785*
		(-0.68)		(-0.35)		(0.97)		(1.83)

(continued)

Table 6. – *continued*

Cash Holdings		-0.0187		-0.0028		-0.0590		0.0220
		(-1.04)		(-0.13)		(-0.83)		(0.30)
Ln Assets per Employee		-0.0004		-0.0003		-0.0104*		-0.0036
		(-0.29)		(-0.20)		(-1.82)		(-0.62)
Constant	0.0043	0.0120	0.0075	0.0118	-0.0512	-0.0760	-0.0330	-0.0874**
	(0.49)	(1.18)	(0.75)	(1.01)	(-1.38)	(-1.95)	(-0.78)	(-2.09)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	277	239	231	201	277	239	231	201
Adjusted R-squared	0.1881	0.1530	0.1496	0.1378	0.3466	0.3426	0.2692	0.3164

This table presents estimated coefficients from regressions of Brexit exposure on a set of firm characteristics. In these specifications we employ alternative measures of internationalization. Brexit exposure is measured alternatively as the Brexit beta or the stock price reaction to the Brexit vote.
Brexit beta (β_{Bi}) is estimated from the model:
$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,
where r_{it} is stock i's return on day t and x_t is the scaled change in the probability of a Brexit vote on day t implied by bookmakers' odds. β_{Bi} is negative where firm returns fall in response to an increase in the probability of a Brexit vote. The model is estimated over 84 trading days between February 20, 2016 and June 22, 2016. The stock price reaction to the Brexit vote ($BHR(0,1)_i$) is measured as the buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016).
The independent variables relate to firm characteristics and are: *Foreign Sales* is sales generated from foreign operations divided by total sales. *Foreign Assets* is assets of foreign operations divided by total assets. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Ln Assets per Employee* is the natural logarithm of the ratio of total assets to the number of employees. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively. Regressions (ii), (iv), (vi) and (viii) are run for non-financial firms only.

Table 7. Alternative Estimates of Brexit Exposure

		Mean	Std dev	Min	Q1	Median	Q3	Max
Panel A: Alternative Estimates of Brexit Beta								
(i)	Change in Leave Probability Not Scaled	-0.164	0.206	-0.737	-0.270	-0.170	-0.091	2.263
(ii)	Change in Leave Probability Scaled by Previous Probability	-0.048	0.057	-0.207	-0.079	-0.051	-0.027	0.567
(iii)	Current and Lagged Change in Leave Probability	-0.030	0.039	0.158	-0.053	-0.030	-0.015	0.341
(iv)	Controlling for FTSE All Share Returns	-0.005	0.034	-0.093	-0.021	-0.008	0.006	0.420
(v)	Controlling for S&P500 Returns and Changes in VIX	-0.017	0.036	-0.112	-0.033	-0.020	-0.006	0.464
Panel B: Alternative Estimates of Market Reaction to Brexit Vote								
(vi)	Return Day 0	-0.067	0.068	-0.320	-0.093	-0.054	-0.023	0.170
(vii)	BHAR(0,1) CAPM-Adjusted	-0.080	0.112	-0.454	-0.149	-0.068	-0.035	0.333
(viii)	BHAR(0,1) Fama-French-Adjusted	-0.023	0.112	-0.435	-0.099	-0.016	0.049	0.540

This table presents descriptive statistics for alternative estimates of individual firms' Brexit betas (Panel A) and stock price reactions to the Brexit vote (Panel B). In rows (i) and (ii) Brexit beta is defined as β_{Bi} estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,

where r_{it} is stock i's return on day t. In row (i) x_t is the absolute (not scaled) change in the probability of a Brexit vote on day t implied by bookmakers' odds, and in row (ii) it is scaled by the previous day's probability (percentage change). In row (iii) Brexit beta is calculated as $(\beta_{B1i} + \beta_{B2i})$, estimated from the model:

$r_{it} = \beta_{0i} + \beta_{B1i} x_t + \beta_{B2i} x_{t-1} + \varepsilon_{it}$,

where r_{it} is stock i's return on day t and x_t is the change in the probability of a leave (Brexit) vote on day t scaled by the distance from 0.5 on day *t-1*. In row (iv) Brexit beta is defined as β_{Bi} estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{mi} r_t^{FTSE} + \varepsilon_{it}$,

where r_{it} is defined as above, x_t is the change in the probability of a leave (Brexit) vote on day t scaled by the distance from 0.5 on day *t-1*, and r_t^{FTSE} is the return on the FTSE All Share index on day t. In row (v) Brexit beta is defined as β_{Bi} estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{S\&P500} + \beta_{m2i} r_{t-1}^{S\&P500} + \beta_{v1i} \Delta VIX_t + \beta_{v2i} \Delta VIX_{t-1} + \varepsilon_{it}$,

where r_{it} and x_t are defined as above, $r_t^{S\&P500}$ is the return on the S&P500 index on day t, and ΔVIX_t is the change in the value of the VIX index on day t. All models are estimated over 84 trading days between February 20, 2016 and June 22, 2016. In row (vi) the stock price reaction is calculated as the stock return on the day of the referendum result (June 24, 2016). In rows (vii) and (viii) the stock price reaction is measured as the stock's buy-and-hold abnormal return (*BHAR(0,1)*) calculated as the stock's buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016) less the expected buy-and-hold return estimated on the basis of the CAPM model or the Fama-French model, respectively. Betas of the CAPM and Fama-French factors are estimated using daily data over 2015. The sample includes all U.K. firms listed on the London Stock Exchange on January 1, 2016, excluding Equity Investment Instruments, Non-Equity Investment Instruments, Real Estate Investment and Services, Real Estate Investment Trusts and the least liquid firms (firms with more than 8 zero daily returns between February 20, 2016 and June 22, 2016).

Table 8. Determinants of Brexit Exposure – Alternative Estimates of Brexit Beta

	Dependent Variable: Alternative Estimates of Brexit Beta									
	Change in Leave Probability Not Scaled		Change in Leave Probability Scaled by Previous Probability		Current and Lagged Change in Leave Probability		Controlling for FTSE All Share Returns		Controlling for S&P500 Returns and Changes in VIX	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)
Ln Foreign Country Count	0.0340***	0.0317**	0.0103***	0.0096**	0.0092***	0.0091***	0.0063***	0.0064***	0.0057***	0.0056***
	(2.95)	(2.36)	(3.01)	(2.41)	(4.14)	(3.57)	(3.79)	(3.28)	(3.13)	(2.60)
MB Ratio	-0.0050**	-0.0041	-0.0015**	-0.0012	-0.0007	-0.0008*	-0.0009**	-0.0010**	-0.0007*	-0.0007*
	(-2.34)	(-1.58)	(-2.34)	(-1.52)	(-1.50)	(-1.69)	(-2.43)	(-2.58)	(-1.84)	(-1.71)
Sales Growth	-0.0152	-0.0630	-0.0054	-0.0179	-0.0092	-0.0235*	-0.0003	-0.0008	0.0003	-0.0083
	(-0.24)	(-1.12)	(-0.30)	(-1.04)	(-0.77)	(-1.96)	(-0.03)	(-0.09)	(0.03)	(-0.89)
Capex		0.2016		0.0492		0.0879		0.0359		0.0464
		(0.72)		(0.60)		(1.59)		(0.84)		(1.02)
R&D Expenses		-0.0097		-0.0134		0.0335*		0.0045		0.0144
		(-0.09)		(-0.43)		(1.85)		(1.26)		(0.76)
R&D Dummy		0.0281		0.0093		0.0056		0.0045		0.0032
		(1.25)		(1.44)		(1.18)		(1.26)		(0.95)
Ln Firm Size	-0.0297***	-0.0370***	-0.0082***	-0.0102***	-0.0065***	-0.0075***	-0.0026***	-0.0040***	-0.0052***	-0.0063***
	(-4.49)	(-4.56)	(-4.14)	(-4.28)	(-5.03)	(-4.62)	(-2.68)	(-3.24)	(-4.94)	(-4.83)
ROE	0.1025***	0.1012***	0.0317***	0.0305***	0.0153***	0.0162***	0.0110**	0.0132***	0.0136***	0.0150***
	(3.66)	(3.22)	(3.75)	(3.22)	(2.68)	(2.68)	(2.33)	(2.84)	(2.93)	(3.21)
Foreign Ownership	0.0025	0.0377	-0.0006	0.0108	0.0038	0.0098	0.0035	0.0082	-0.0012	0.0035
	(0.05)	(0.79)	(-0.05)	(0.76)	(0.41)	(1.03)	(0.49)	(1.10)	(-0.16)	(0.44)
E.U. Lobbying	0.9854	6.1282	0.1880	1.6598	-0.4187	0.5753	0.3456	0.8819	0.2299	0.8692
	(0.28)	(1.28)	(0.19)	(1.18)	(-0.64)	(0.60)	(0.73)	(1.10)	(0.45)	(1.06)
Single Market Workforce	0.2450	0.2335	0.0740	0.0744	0.0171	0.0030	0.0498**	0.0430*	0.0435	0.0379
	(1.41)	(1.25)	(1.43)	(1.35)	(0.48)	(0.08)	(2.25)	(1.79)	(1.60)	(1.26)
Leverage		-0.0607		-0.0201		-0.0113		-0.0002		-0.0055
		(-0.90)		(-1.04)		(-0.80)		(-0.02)		(-0.59)

(continued)

Table 8. – *continued*

Cash Holdings		-0.1562		-0.0407		-0.0422**		-0.0067		-0.0167
		(-1.39)		(-1.25)		(-2.03)		(-0.36)		(-0.88)
Ln Assets per Employee		0.0071		0.0020		0.0006		0.0009		0.0012
		(0.78)		(0.76)		(0.31)		(0.61)		(0.73)
Constant	-0.0129	0.0400	-0.0071	0.0070	-0.0011	0.0043	-0.0040	0.0012	0.0082	0.0142
	(-0.23)	(0.61)	(-0.43)	(0.36)	(-0.10)	(0.33)	(-0.48)	(0.12)	(0.94)	(1.35)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	297	251	297	251	297	251	297	251	297	251
Adjusted R-squared	0.1713	0.1415	0.1749	0.1456	0.1973	0.1570	0.2502	0.2641	0.1641	0.1564

This table presents estimated coefficients from regressions of Brexit exposure on a set of firm characteristics, where Brexit exposure is represented by the Brexit beta, estimated using the alternative approaches set out in Panel A of Table 7. In columns (i)-(iv) Brexit exposure (β_{Bi}) is estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \varepsilon_{it}$,

where r_{it} is stock *i*'s return on day *t*. In columns (i) and (ii) x_t is the absolute (not scaled) change in the probability of a Brexit vote on day *t* implied by bookmakers' odds, and in columns (iii) and (iv) it is scaled by the previous day's probability (percentage change). In columns (v) and (vi) Brexit exposure is calculated as ($\beta_{B1i} + \beta_{B2i}$), estimated from the model:

$r_{it} = \beta_{0i} + \beta_{B1i} x_t + \beta_{B2i} x_{t-1} + \varepsilon_{it}$,

where r_{it} is stock *i*'s return on day *t* and x_t is the change in the probability of a leave (Brexit) vote on day *t* scaled by the distance from 0.5 on day *t-1*. In columns (vii) and (viii) the exposure is defined as β_{Bi} estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{FTSE} + \varepsilon_{it}$,

where r_{it} is defined as above and x_t is the change in the probability of a leave (Brexit) vote on day *t* scaled by the distance from 0.5 on day *t-1*. r_t^{FTSE} is the return on the FTSE All Share index on day *t*. In columns (ix) and (x) the exposure is defined as β_{Bi} estimated from the model:

$r_{it} = \beta_{0i} + \beta_{Bi} x_t + \beta_{m1i} r_t^{S\&P500} + \beta_{m2i} r_{t-1}^{S\&P500} + \beta_{v1i} \Delta VIX_t + \beta_{v2i} \Delta VIX_{t-1} + \varepsilon_{it}$,

where r_{it} and x_t are defined as above, $r_t^{S\&P500}$ is the return on the S&P500 index on day *t*, and ΔVIX_t is the change in the value of the VIX index on day *t*. All models are estimated over 84 trading days between February 20, 2016 and June 22, 2016.

The independent variables relate to firm characteristics and are: *Ln Foreign country count* is the natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is

(continued)

Table 8. – *continued*

the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Ln Assets per Employee* is the natural logarithm of the ratio of total assets to the number of employees. All variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively. Regressions (ii), (iv), (vi), (viii) and (x) are run for non-financial firms only.

Table 9. Determinants of Brexit Exposure – Alternative Estimates of Market Reaction to Brexit Vote

	Dependent variable: Alternative Estimates of Market Reaction to Brexit Vote					
	Return Day 0		BHAR(0,1) CAPM-Adjusted		BHAR(0,1) Fama-French-Adjusted	
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Ln Foreign Country Count	0.0349***	0.0309***	0.0541***	0.0508***	0.0450***	0.0412***
	(6.06)	(4.99)	(6.78)	(5.76)	(6.08)	(4.89)
MB Ratio	0.0008	-0.0002	0.0003	-0.0015	-0.0009	-0.0023
	(0.93)	(-0.18)	(0.22)	(-1.09)	(-0.56)	(-1.23)
Sales Growth	-0.0564**	-0.0568**	-0.1318***	-0.0934**	-0.0643*	-0.0583
	(-2.41)	(-1.99)	(-3.25)	(-2.11)	(-1.76)	(-1.37)
Capex		0.1225		-0.0153		0.0548
		(1.47)		(-0.11)		(0.36)
R&D Expenses		-0.0243		-0.0219		0.0416
		(-0.54)		(-0.32)		(0.42)
R&D Dummy		0.0217**		0.0339***		0.0132
		(2.52)		(2.72)		(0.97)
Ln Firm Size	-0.0103***	-0.0093***	-0.0034	-0.0054	-0.0207***	-0.0220***
	(-3.53)	(-2.92)	(-0.85)	(-1.21)	(-5.13)	(-4.49)
ROE	-0.0089	-0.0056	-0.0050	0.0078	-0.0007	0.0112
	(-1.02)	(-0.66)	(-0.36)	(0.61)	(-0.04)	(0.48)
Foreign Ownership	0.0090	0.0185	0.0145	0.0350	0.0260	0.0529
	(0.43)	(0.84)	(0.47)	(1.12)	(0.76)	(1.49)
E.U. Lobbying	1.1529	3.3335*	1.8116	4.5841	0.4886	2.3161
	(0.87)	(1.96)	(0.94)	(1.38)	(0.26)	(0.85)
Single Market Workforce	0.0509	0.0152	0.0067	-0.0291	0.0816	0.0335
	(0.77)	(0.23)	(0.06)	(-0.25)	(0.62)	(0.25)
Leverage		0.0281		0.0679*		0.0109
		(1.13)		(1.94)		(0.30)
Cash Holdings		0.0261		-0.0088		-0.0429
		(0.64)		(-0.13)		(-0.61)
Ln Assets per Employee		0.0007		0.0005		0.0015
		(0.19)		(0.09)		(0.25)
Constant	-0.0326	-0.0675**	-0.0795**	-0.1089***	0.1050***	0.1064***
	(-1.06)	(-2.23)	(-2.03)	(-2.83)	(3.28)	(2.74)
Industry Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	297	251	297	251	297	251
Adjusted R-squared	0.3186	0.2956	0.4202	0.4317	0.3599	0.3368

This table presents estimated coefficients from regressions of Brexit exposure on a set of firm characteristics, where Brexit exposure is represented by the stock price reaction to the Brexit vote, estimated using the alternative approaches set out in Panel B of Table 7. In columns (i) and (ii) the stock price reaction is calculated as the stock return on the day of the referendum result (June 24, 2016). In columns (iii)-(vi) the stock price reaction is the stock's buy-and-hold abnormal return (*BHAR(0,1)*) calculated as the stock's buy-and-hold return on the day of the referendum result (Day 0 – June 24, 2016) and the following trading day (Day 1 – June 27, 2016) less the expected buy-and-hold return estimated on the basis of the CAPM model (columns (iii) and (iv)) or the Fama-French model (columns (v) and (vi)). Betas of the CAPM and Fama-French factors are estimated using daily data over 2015.

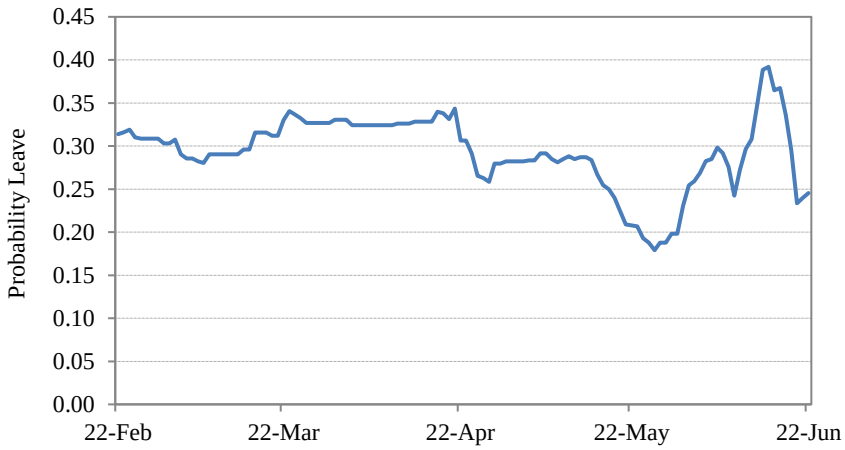
The independent variables relate to firm characteristics and are: *Ln Foreign country count* is the natural logarithm of 1 plus the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published

(continued)

Table 9. – *continued*

before the Brexit referendum. *MB Ratio* is the ratio of the year-end share price to book value per share. *Sales Growth* is the three-year change in revenues. *Capex* is capital expenditures scaled by the previous year's total assets. *R&D Expenses* is research and development expenses scaled by total sales, and it is set to zero for missing data. *R&D Dummy* is a dummy variable equal to one if the data for research and development expenses is non-missing, and equal to zero otherwise. *Ln Firm Size* is the natural logarithm of the firm's stock market capitalization. *ROE* (Return on Equity) is net income less preferred dividends divided by the average of current year's and previous year's common equity. *Foreign Ownership* is the percentage of shares outstanding held by investors located outside of the U.K. *E.U. Lobbying* is the midpoint of the range of the declared E.U. lobbying costs (converted to GBP) scaled by total sales and multiplied by 100. *Single Market Workforce* is the fraction of the workforce in the sector the firm belongs to (defined by the 2-digit British SIC code) born in a European Single Market country other than the U.K. *Leverage* is the ratio of total debt to total assets. *Cash Holdings* is cash scaled by total assets. *Ln Assets per Employee* is the natural logarithm of the ratio of total assets to the number of employees. All dependent and independent variables are winsorized at the 1st and 99th percentile. *t*-statistics based on heteroskedasticity-consistent standard errors of the coefficients are reported in parentheses. ***, **and * denote significance at the 1, 5, and 10 percent level, respectively. Regressions (ii), (iv) and (vi) are run for non-financial firms only.

Figure 1. Implied Probability of Leave (Brexit) Vote



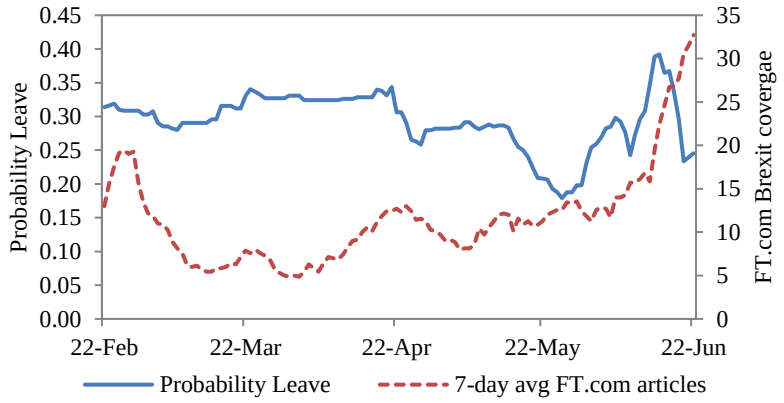
This figure presents the probability of a leave (i.e. Brexit) vote between February 22, 2016, the first trading day after the EU membership referendum was announced, and June 22, 2016, one day before the referendum. The probability is calculated as the average implied probability from odds by Coral, Ladbrokes, Paddy Power and William Hill, with probabilities for individual bookmakers calculated as:

$prob_{jt}^{Leave} = \frac{1/odds_{jt}^{Leave}}{1/odds_{jt}^{Leave}+1/odds_{jt}^{Remain}}$,

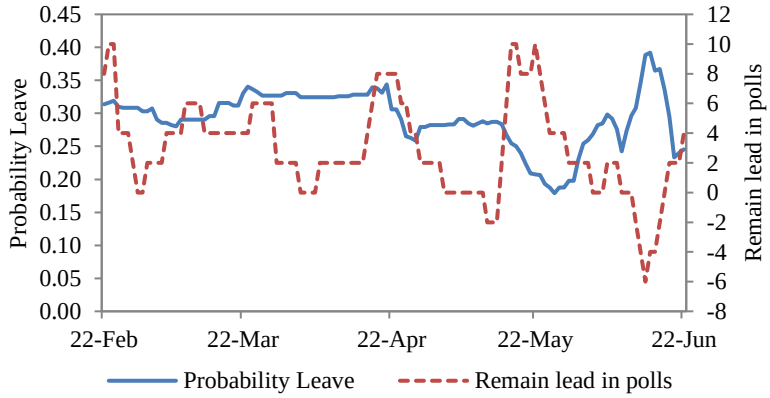
where $odds_{jt}^{Leave}$ ($odds_{jt}^{Remain}$) is the end of day *t* decimal odds offered by bookmaker *j* on the leave (remain) outcome of the referendum.

Figure 2. Probability of Leave (Brexit) Vote and Brexit News Coverage, Opinion Polls and GBP/USD Exchange Rate

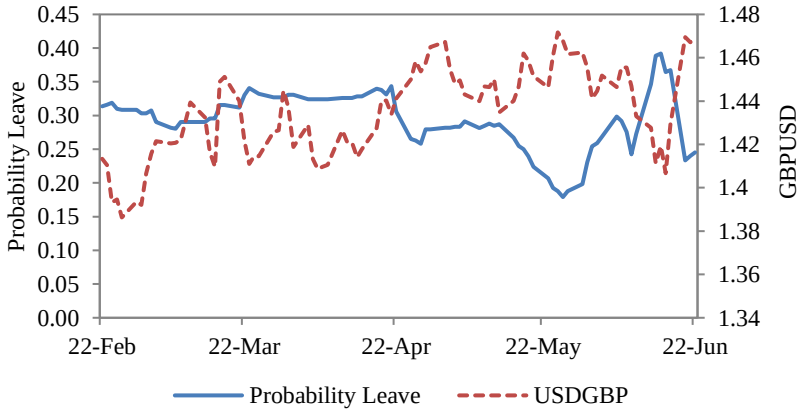
Panel A. Probability Leave vs. Brexit News Coverage



Panel B. Probability Leave vs. Remain lead in polls

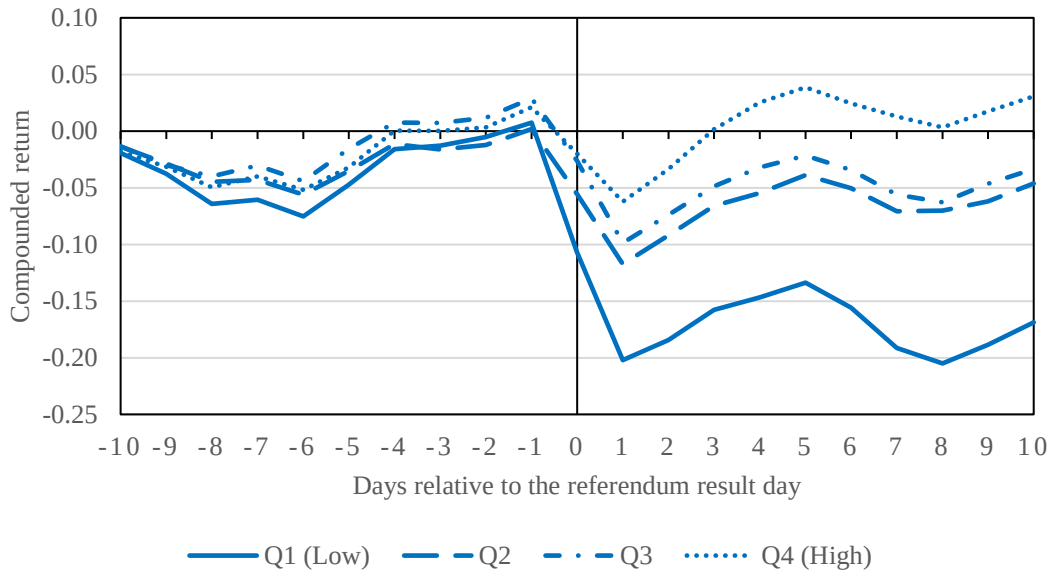


Panel C. Probability Leave vs. GBP/USD exchange rate



This figure presents the probability of a leave (i.e. Brexit) vote implied by bookmakers' odds plotted against the 7-day average of Financial Times (FT.com) articles with the word 'Brexit' (Panel A), the percentage point lead of the remain vote (over the leave vote) in opinion polls (Panel B) and the GBP/USD exchange rate (Panel C). The opinion polls series is based on the average of the 6 most recent polls and the leave/remain support is calculated excluding 'don't knows'.

Figure 3. Internationalization and Market Reaction to Brexit Vote



This figure presents performance of equally-weighted portfolios of stocks formed on the basis of quartiles of the distribution of *Foreign Country Count (raw)* - the number of foreign countries mentioned in the firm's most recent (2015/2016) annual report published before the Brexit referendum. Q1 (Q4) is the portfolio of firms in the bottom (top) quartile of the distribution of the measure. Day 0 is the day of the referendum result (June 24, 2016).